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Empirical Evidence on the Recent Behavior and Usefulness of Simple-Sum and Weighted Measures of the Money Stock

"We must have a good definition of Money, For if we do not, then what have we got, But a Quantity Theory of no-one-knows-what..."

Boulding (1969, p. 555)

THE FEDERAL RESERVE BANK of St. Louis has been, for the last three decades or so, at the center of an approach to macroeconomic policy which became universally known as "Monetarism." Indeed, the very term entered the public domain through an article in the Federal Reserve Bank of St. Louis' *Review* by Karl Brunner in 1968. The central tenet of monetarism was that there is a stable demand function for something called "money." Policy advice came down to recommending that the monetary authorities should deliver a steady rate of the growth of money within some target range.

The 1970s were a good time for monetarists. Velocity in the United States appeared to be on a stable trend, and the adoption of floating exchange rates generated a need for independent measures of monetary stance in most of the industrial countries. Monetary targeting was widely adopted and monetarism became a worldwide credo. Since the end of the 1970s, however, life has been much harder for monetarists. The stability of empirical monetary relationships became much more difficult to maintain, and government after government has given up even the notional attempt to target monetary aggregates. The allegedly monetarist government of Margaret Thatcher abandoned monetary targets in the United Kingdom in 1985. The Chairman of the Federal Reserve Board has recently announced that the Fed has ceased to monitor M2 and, instead, will be using the real interest rate as an indicator of monetary stance. Only the Bundesbank appears to be retaining any faith in the significance of monetary aggregates, though they have been widely criticized for so doing. (Norbert Walter, the chief economist of Deutsche Bank, has, for example, been quoted as saying that "...M3, the broad money supply indicator targeted by the central bank, was obviously distorted and devalued as an indicator." *Financial Times*, August 10, 1993, p. 2).

The standard explanation for why previously stable monetary relationships have broken down is financial innovation. In particular, liberalization and competition in banking have generated shifts in demand between components of money which have undermined earlier empirical regularities. Interest payments on transaction deposits have made it more difficult to distinguish money held for transaction from money held for savings.

Robert Rasche (1993) in his paper to the St. Louis Fed conference 12 months ago identified the beginning of the 1980s as a time of a critical regime change. This structural change, he claimed, had destroyed the validity of the traditional St. Louis reduced-form methodology as a means for explaining and forecasting the course of GNP. Policy makers around the world have clearly also been convinced that monetary aggregates provide little useful information to guide macro policy.

Presumably, nobody would argue that no guide to monetary policy was necessary. However, the advocates of a simplistic policy based upon any traditional measure of money as the sole guide are disappearing rapidly.

At the theoretical level, the significance of exogenous monetary shocks as a cause of business cycles has been under threat from the so-called Real Business Cycle school. For them, monetary disturbances are not the trigger to cycles but, rather, are an endogenous response to shocks emanating in the real economy. While this approach does not necessarily eliminate the validity of countercyclical monetary policy, it certainly reduces the significance of the traditional monetarist line that monetary shocks are the primary trigger to the cycle. Several recent empirical studies have apparently produced evidence to support the contention that money does not have any explanatory power—at least for real economic activity. (De Long and Summers, 1988; Friedman and Kuttner, 1992, 1993.)

The consensus view emerging from all of this appears to be that trying to target and control money is no longer a very sensible thing for policy makers to do. Monetary policy is now mainly about setting short-term interest rates, despite all the well-known difficulties that choosing the "correct" interest rate entails (Friedman, 1959).

This paper follows an alternative line of reasoning, for which there is an overwhelming theoretical case. There has been a major measurement error in virtually all of the previous literature on money. Instability in empirical relationships has been primarily due to the fact that simple-sum measures of money are not admissible aggregates on index-theoretic grounds. This error has been especially important in a period when characteristics of components which are added together have been changing.

We do not claim that correction of this measurement error salvages entirely the role of money as a macroeconomic indicator (though such may still be the case). Rather, our primary focus is to see whether acceptable indexes of money outperform traditional money measures in conventional tests. As is often the case in applied studies, the evidence turns out to be mixed but leaning in favor of the superiority of weighted over simple-sum aggregates.

Before presenting our own empirical evidence, we shall first review briefly the evolution of the concept of money and then the case for an appropriately constructed index.

What Is Money?

The definition of money has not been static over time. The first identifiable measure of money was undoubtedly the stock of the physical commodity which served as currency—typically precious metal. At some point, certainly by the 18th century in England, it was clear that bank notes had become a major element of the money stock so that a monetarist at that time would have had to extend the definition of money to include notes plus specie in the hands of the public. By the 19th century, financial innovation had moved things a stage further and the relevant concept of money had expanded yet again to include bank deposits, which could be used on demand and could be transferred by writing a check.

In recent times, the issue has been: Which of the other highly liquid assets held by the public should be included? The Radcliffe view in the United Kingdom and the view of Gurley and Shaw in the United States was that the boundary between money and other liquid assets was impossible to draw because so many close substitutes were available. This contention was countered successfully for a while by the evidence that elasticities of substitution were relatively small (Chetty 1969) and also by the evidence that predictions of monetarist approaches were fairly robust to minor definitional changes. In other words, the general message of the evidence was not so different if one used M1 or M2, or even M3.

Such a defense would be much harder to maintain today than it was 15 years ago. The introduction of interest payments on checking accounts in the United States led to a major reversal of the velocity trend—at least for M1 in about 1980. In the United Kingdom, abolition of quantitative ceilings on bank intermediation, also in 1980, led to a period of rapidly rising broad money coinciding with very slow narrow money growth. The innovations which followed were clearly associated with big movements of deposits from non-interest bearing to interest-bearing accounts. In such circumstance, neither narrow nor broad money proved to be reliable indicators—at least in the short term.

It would be a mistake to believe that the composition changes of the 1980s were a new phenomenon. In Volume I of *A Treatise on Money*, Keynes argued that an unchanged quantity of money could conceal important changes in circulation as holders transferred money between cash and savings deposits, and between income and business accounts. In Volume II, he reported the statistical finding that the proportion of deposit (savings) accounts to total accounts had risen in Britain from 38 percent to 46 percent between 1920 and 1926. According to Keynes, "... The continual transference from current to deposit accounts ... [acted as] a concealed measure of deflation..." (Keynes, 1930b, p. 10) sufficient to explain a drop in the price level of 20 percent over the period.

There is nothing remarkable about the fact that these composition changes have been noticed before. What is remarkable is that so many economists were happy to ignore them for so long in the post-World War II period. Partly, this was because the regulatory regime in most countries (interest ceilings and/or quantitative controls on intermediation) limited for some time the significance of the interface between checking and savings accounts, as well as the significance of nonbank competitors.

Money Measurement

A substantial amount of literature discusses the concept of money and its measurement (see Fisher, 1989, Chapter 1, for a survey). At the risk of oversimplifying, it is sufficient for present purposes to note that the traditional reason for regarding money as critically different from other assets is that it has a direct role in transactions and, hence, has a direct role in the trading activity of a market economy. According to the Quantity Theory, the money stock will determine the general level of prices (at least in the long term) and, according to monetarists, it will influence real activity in the short run.

For this reason, empirical measures of the money stock have tried to identify as components of money those instruments which can be used directly in transactions. The problem of our time is that a whole range of types of deposits which can be spent, more or less, directly also yield an interest rate and could, thus, be chosen as a form of savings as well.

From a micro-demand perspective, it is hard to justify adding together assets which have different and varying yields (Barnett, Fisher and Serletis, 1992). It has long been known that only things that are perfect substitutes can be combined as one commodity. There is ample evidence that the assets which are commonly combined in money measures are not in fact perfect substitutes.

From a micro-foundations perspective this leaves only two alternatives. The first is to restrict attention to a very narrow definition of money, which only needed non-interest bearing components. The alternative is to construct an index number of "monetary services" which could, in principle, capture the transactions services yielded by a wide range of financial assets in a superlative way (Diewert 1976, 1978). Two potential index numbers are the Divisia index proposed by Barnett (1980) and the Currency Equivalent (CE) index proposed by Rotemberg (1991) at the St. Louis conference in 1989.

The attraction of both of these monetary services indicators is that they internalize the substitution effects between components of a potential aggregate and, thus, solve the problem of composition changes which was discussed above. They do not in themselves guarantee the weak separability of any chosen aggregate, but they do approximate optimal aggregator functions for those collections of aggregates which have been found "admissible" on separability grounds (Belongia and Chalfant, 1989).

The theoretical case for weighted monetary aggregates is overwhelming—at least to anyone with a training in microeconomics and/or index number theory. The only objection could be on the grounds that it does not make an improvement over flawed simple-sum aggregates in practice. There has been a significant accumulation of evidence, however, to suggest that Divisia aggregates outperform their simple-sum equivalents. For example, Barnett (1980) showed that some apparent shifts in money demand in the United States were removed when Divisia measures replaced simple sum. Barnett and Spindt (1979) showed the informational superiority of Divisia over simple-sum measures. Belongia and Chalfant (1989) find Divisia M1A to have superior informational content to other admissible aggregates. Barnett, Offenbacher and Spindt (1984) also find evidence for the superiority of Divisia. Further support is provided by Serletis (1988). Lindsey and Spindt (1986) is one of the few papers which have looked at this comparison to come out against Divisia, though Fisher and Serletis (1989) is inconclusive.

Belongia (1993) has recently discovered that using weighted, as opposed to simple-sum, monetary aggregates alters significantly the conclusions that should have been reached by several recent influential studies. These studies have, on the whole, adduced evidence that money is not a "cause" of cycles in real activity. Hence, this suggests that the problems with tests of money in the economy in recent years may be more due to bad measurement theory rather than to an instability in the link between the true money and the economy. Rather than a problem associated with the Lucas Critique, it could instead be a problem stemming from the "Barnett Critique."

The idea of weighted monetary aggregates has spread outside the United States. Studies include Horne and Martin (1989) for Australia; Cockerline and Murray (1981) and Hostland, Poloz and Storer (1987) for Canada; Ishida (1984) for Japan; Yue and Fluri (1991) for Switzerland; and Belongia and Chrystal (1991) and Drake and Chrystal (forthcoming) for the United Kingdom. A recent Bank of England study in the United Kingdom context concludes: "A Divisia measure of money appears to have some leading indicator properties for predicting both nominal output and inflation...a case can clearly be made for including Divisia in the range of indicators analyzed by the authorities when forming their judgments on monetary conditions." (Fisher, Hudson and Pradhan, 1993, p. 63).

A variation on the traditional "closed economy" tests is provided by Chrystal and MacDonald (1993). They point out that exchange rate models have been just as dependent upon money measures as have demand for money studies or reduced form tests of monetary policy. It is no coincidence that exchange rate equations started to misbehave at the same time as velocity trends appeared to shift (in the early 1980s). By replacing simple-sum aggregates in an exchange rate model by Divisia aggregates, for the dollar-pound rate, they show that a simple, flexible, price monetary model can be salvaged as a long-run proposition. They also find that, when Divisia measures are used, the short-run forecasting performance is far superior on out-of-sample tests.

We now turn to some empirical results of our own. The results we shall present fall into two distinct sections. In the first section, we report comparisons of simple-sum and weighted measures of the money supply in the context of St. Louis Equations. The dependent variable is accordingly nominal GNP. We are aware of the problems encountered in the past with such methods (Rasche, 1993). However, it is a simple, familiar and well-known context within which to compare money measures. We are not concerned with the absolute validity of the results but only with the relative performance of different measures. Non-nested testing techniques were used to distinguish between various indicators of money.

In the second section, we use the more sophisticated modern time-series methodology to test for the existence of short-run and long-run causal links between money and real activity. It is this latter question which has dominated the recent literature. We add to this literature both by including alternative money measures and by providing international comparisons.

EMPIRICAL RESULTS WITH ST. LOUIS EQUATIONS

In this section, we report results of comparisons between traditional simple-sum aggregates, Divisia measures and the Rotemberg Currency Equivalent (CE) measure. We use the environment of a modified St. Louis Equation as a vehicle for these comparisons, and we use non-nested testing methods to identify superior informational content. We are well aware with all the difficulties associated with the St. Louis Equation methodology. If we cannot use this structure at a St. Louis Fed conference, however, where else can we? More seriously, this method offers simplicity and transparency. It does at least give us a feel for the properties of the data we are dealing with. A methodology more acceptable to the econometric purist will be reported in the following section.

None of the data we used was original to this study. The bulk of it was made available to us by Michael Belongia at the Federal Reserve Bank of St. Louis, though the U.K. Divisia series (post-1977) was constructed by the Bank of England (Fisher, Hudson and Pradhan, 1993). It should be noted that the time period of the study differs for each country, depending upon data availability. Data definitions also vary from country to country, but space does not permit an extensive discussion of such differences. Seasonally adjusted data were used in all cases.

The dependent variable is taken as the first difference of the log of nominal GDP or GNP. The first difference of the log of nominal government spending (federal in the United States case) on goods and services is used as a fiscal variable in all cases. A world trade variable was tested as an external demand variable but was not found to add explanatory power in the countries tested. Also tested was an interest rate variable. This was found to be important in this context only for the United States. Hence, the U.S. Equation includes the first difference of the Treasury bill rate.

The original St. Louis Equation contained lags of order 0-3. On quarterly data, most economists would expect to use at least 0-4, so, given the short data series for some countries, this is the standard lag length we adopted.

In parallel to the simple St. Louis Equation format, we also report tests in a version of the equation which includes the lagged dependent variable, lagged 1-4 periods. Additionally in this latter context we report an F test on the exclusion of money from the equation entirely. This provides useful information, not only about the relative informational content of different money measures but also about whether money matters at all. In some cases Divisia money matters but simple-sum money does not. The reverse is never true.

The basic test is to use the same equation in one case with simple-sum money and in another case Divisia or CE money. Three test statistics are reported for comparisons between the two formulations—the Davidson and MacKinnon J-test, the Fisher and McAleer JA-test and the Akaike Information Criterion (AIC). Other tests have been monitored, including the NT test of Pesaran and Godfrey and the Wald-type test. These other tests differ in detail but they do not alter the overall picture produced. Accordingly, they are not reported here. We refer to the J-test and the JA-test as being inconclusive when both formulations reject each other and indeterminate if neither rejects the other.

The results are reported in Tables 1 to 7 for the United States, the United Kingdom, Australia, Germany, Switzerland, Canada and Japan, respectively. Let us consider each.

United States

The U.S. results are summarized in Table 1. Simple-sum aggregates M1 and M1A in general dominate their Divisia equivalents. From M2 onwards to broader aggregates, however, the domination is reversed. This is clear for M2 and M3, though the difference between Divisia L and simple-sum L is probably not significant. This general picture is not altered by the inclusion or exclusion of the lagged dependent variable.

From the F-tests it is clear that simple-sum M1A, Divisia M1A and Divisia M1 do not add significant explanatory power to the equation at normal significance levels. However, Divisia M2 has the greatest informational content of all the aggregates tested, though it is only marginally more significant than simple-sum M2.

The CE aggregate holds its own against M1 and M1A, though never establishing statistically significant domination in either direction. It loses out to the broader simple-sum aggregates, however, and also to the broader-based Divisia measures (the latter result is implied but not shown).

Overall, the M2 level of money aggregation seems superior, though the Divisia aggregate at this level does not dominate its simple-sum equivalent sufficiently to make an overwhelming case for preferring one to the other.

United Kingdom

The U.K. results appear in Table 2. There are far fewer aggregates to choose from in the U.K. case. The Bank of England even stopped report-

Table 1

St. Louis Equations for the United States: Simple-Sum vs. Weighted Money

Dependent variable: first difference of the natural log of nominal GNP.
Independent control variables: first difference of the natural log of federal spending on goods and services; first difference of the T-bill rate; the current period value and four lags of each variable are included as regessors.

Part 1: no lagged dependent variable in regression

M1 vs. Divisia M1		
Akaike Information Criterion (AIC)	favors M1	(4.42)
J-test	favors M1	(−.1; 3.06)
JA-test	favors M1	(−.72; 2.26)
M1 vs. Rotemberg Currency Equivalent (CE)		
AIC	favors CE	(−.24)
J-test	inconclusive	(2.74; 2.64)
JA-test	indeterminate	(1.56; 1.39)
M1A vs. Divisia M1A		
AIC	favors M1A	(3.78)
J-test	favors M1A	(−.59; 2.7)
JA-test	favors M1A	(−.67; 2.6)
M1A vs. CE		
AIC	favors CE	(−.55)
J-test	inconclusive	(2.7; 2.4)
JA-test	indeterminate	(1.66; 1.16)
M2 vs. Divisia M2		
AIC	favors Divisia M2	(−1.1)
J-test	favors Divisia M2	(2.42;1.8)
JA-test	favors Divisia M2	(2.04;1.4)
M2 vs. CE		
AIC	favors M2	(8.75)
J-test	inconclusive	(2.4; 4.9)
JA-test	favors M2	(.92; 3.6)
M3 vs. Divisia M3		
AIC	favors Divisia M3	(−1.76)
J-test	favors Divisia M3	(2.4; 1.5)
JA-test	favors Divisia M3	(1.9; 1.2)
M3 vs. CE		
AIC	favors M3	(6.45)
J-test	inconclusive	(3.07; 4.7)
JA-test	inconclusive	(2.05; 2.72)
L vs. Divisia L		
AIC	favors Divisia L	(−.31)
J-test	inconclusive	(2.35; 2.18)
JA-test	inconclusive	(1.6; 1.34)
L vs. CE		
AIC	favors L	(7.27)
J-test	inconclusive	(2.9; 4.8)
JA-test	inconclusive	(2.2; 3.98)

Note: The Akaike Information Criterion is an adjusted difference between two values of the likelihood function. It indicates the direction of informational advantage but has no critical bounds. The J and JA tests are *t*-statistics for the rejection of one model over the other and then the reverse. *"Inconclusive" = both significant; "Indeterminate" = neither significant.* Data period is 60:1–92:4.

Table 1 (continued)

Part 2: four lags of the dependent variable included

M1 vs. Divisia M1		
AIC	favors M1	(3.74)
J-test	favors M1	(.27; 2.8)
JA-test	indeterminate	(−.45; 1.78)
M1 vs. CE		
AIC	favors M1	(.46)
J-test	inconclusive	(2.49; 2.59)
JA-test	indeterminate	(1.6; 1.15)
M1A vs. Divisia M1A		
AIC	favors M1A	(3.2)
J-test	favors M1A	(−.42; 2.44)
JA-test	favors M1A	(−.55; 2.3)
M1A vs. CE		
AIC	favors CE	(−.84)
J-test	inconclusive	(2.7; 2.3)
JA-test	indeterminate	(1.4;.62)
M2 vs. Divisia M2		
AIC	favors Divisia M2	(−.74)
J-test	inconclusive	(2.4; 2.1)
JA-test	indeterminate	(1.87; 1.56)
M2 vs. CE		
AIC	favors M2	(5.76)
J-test	inconclusive	(2.4; 4.3)
JA-test	favors M2	(.62; 3.4)
M3 vs. Divisia M3		
AIC	favors Divisia M3	(−1.5)
J-test	favors Divisia M3	(2.24; 1.5)
JA-test	indeterminate	(1.63; 1.14)
M3 vs. CE		
AIC	favors M3	(3.4)
J-test	inconclusive	(3.05; 3.99)
JA-test	favors M3	(1.32; 2.26)
L vs. Divisia L		
AIC	favors Divisia L	(−.42)
J-test	inconclusive	(2.38; 2.21)
JA-test	indeterminate	(1.42; 1.29)
L vs. CE		
AIC	favors L	(3.93)
J-test	inconclusive	(2.9; 4.0)
JA-test	favors L	(1.85; 3.4)

Table 1 (continued)

Part 3: F-tests on exclusion of money from St. Louis Equation

		probability
M1	F(5,107)	= 2.36 [0.045]
M1A	"	= 1.88 [0.103]
M2	"	= 4.43 [0.001]
M3	"	= 3.49 [0.006]
L	"	= 3.69 [0.004]
Divisia M1	"	= 1.01 [0.418]
Divisia M1A	"	= 0.73 [0.600]
Divisia M2	"	= 4.73 [0.001]
Divisia M3	"	= 4.09 [0.002]
Divisia L	"	= 3.86 [0.003]
CE	"	= 2.19 [0.060]

Note: Exclusion test conducted in equation including lagged dependent variable shown in Part 2 of the table. This is equivalent to the concept of Granger causality tests, but includes contemporaneous observations on independent variables.

ing M1 and M3 in 1989 because it considered the data too distorted by financial innovation. Hence, the only choice using official statistics is between M0 (the monetary base) and M4. The results show a clear domination of Divisia M4 over simple-sum M4 both with and without the presence of lagged GDP. The non-nested tests, however, make it impossible to choose between Divisia M4 and M0. Also, while the Akaike Information Criterion favors M0 over simple-sum M4, the J-test and the JA-test are inconclusive and indeterminate, respectively. On the other hand, the F-test gives informational advantage to M0, with Divisia M4 running second. Simple-sum M4 has no significant explanatory power at normal probability levels. This suggests that Divisia M4 should replace simple-sum M4 as an indicator of the course of broad money in the United Kingdom.

Australia

Results for Australia appear in Table 3. They show comparisons between M2, M3 and their Divisia equivalents. The information criterion is always in favor of Divisia, and the significant J-tests favor Divisia. More dramatic perhaps are the F-tests which show that neither simple-sum aggregate matters at anything close to normal probability levels, while both Divisia aggregates do have significant informational content. This is probably the clearest case available which illustrates the domination of Divisia over simple-sum aggregates—especially for broad money measures.

Germany

Table 4 contains the results for Germany. The information criterion generally favors Divisia measures over their simple sum counterparts, with the exception of M3 in the absence of the lagged dependent variable. All the J- and JA-tests are indeterminate with the exception of the J-test which shows dominance of Divisia M2 over M2 (in the presence of the lagged dependent variable). The same test for M3 is very close to accepting Divisia M3 as dominating M3.

The overwhelming impression of the German results, however, is that conveyed by the F-tests, which show the very low informational content of all money measures. In this respect, only Divisia M3 is significant at even the 10 percent level and the simple-sum aggregates do not obviously matter at all. This is a surprising result for a country which has a reputation for sound monetary policy and adheres to a simple-sum M3 target. It is possible that the very success of monetary policy is responsible for a low variation of nominal income growth, which makes it hard to establish statistical relationships. However, it is also possible that Divisia money measures do a better job in tracking nominal GDP than their simple-sum equivalents.

Table 2

St. Louis Equations for the United Kingdom: Simple-Sum vs. Weighted Money

Dependent variable: first difference of the natural log of nominal GDP.
Independent control variables: first difference of the natual log of government spending on goods and services.

Part 1: no lagged dependent variable included in regression		
Divisia M4 vs. M4		
AIC	favors Divisia M4	(3.136)
J-test	favors Divisia M4	(1.05; 3.1)
JA-test	favors Divisia M4	(−.45; 2.2)
Divisia M4 vs. M0		
AIC	favors Divisia M4	(.168)
J-test	inconclusive	(2.77; 2.72)
JA-test	indeterminate	(1.52; .96)
M4 vs. M0		
AIC	favors M0	(−3.2)
J-test	inconclusive	(3.5; 2.5)
JA-test	indeterminate	(.49; .77)
Part 2: four lags of dependent variable included		
Divisia M4 vs. M4		
AIC	favors Divisia M4	(2.32)
J-test	favors Divisia M4	(1.3; 2.7)
JA-test	indeterminate	(−.16; 1.82)
Divisia M4 vs. M0		
AIC	favors M0	(−.78)
J-test	inconclusive	(3.17; 2.8)
JA-test	indeterminate	(1.5; .73)
M4 vs. M0		
AIC	favors M0	(−3.69)
J-test	inconclusive	(3.8; 2.7)
JA-test	indeterminate	(−.18; −.36)

Part 3: F-tests on exclusion of money from St. Louis Equation

		probability
M4	F(5, 78)	= 1.45 [0.215]
Divisia M4	"	= 2.33 [0.050]
M0	"	= 2.83 [0.021]

Note: Test is done in equation from Part 2 including lagged dependent variable. Data period is 1968:3–1992:4.

Switzerland

In Switzerland, (Table 5) Divisia aggregates dominate on information grounds, though the JA-test is always indeterminate and the J-test only gives clear dominance to Divisia on one occasion (Divisia M2 beats M2 in the presence of lagged GDP). The F-tests suggest that M1 and Divisia M1 are very similar in informational content (with a tiny advantage to Divisia). Simple-sum M2, by contrast, is overwhelmingly dominated by its Divisia counterpart. This confirms the simple (and obvious) conclusion from other countries that Divisia clearly dominates when it comes to broad money measures, but at the narrow money level it does not make much difference. This is clearly almost a tautology when narrow aggregates have minimal interest-bearing components.

Table 3

St. Louis Equations for Australia: Simple-Sum vs. Weighted Money

Dependent variable: first difference of the natural log of nominal GDP.
Independent control variable: first difference of the natural log of government spending.

Part 1: no lagged dependent variable included in regression		
M2 vs. Divisia M2		
AIC	favors Divisia M2	(−3.74)
J-test	inconclusive	(3.63; 2.67)
JA-test	indeterminate	(−.7; −.19)
M3 vs. Divisia M3		
AIC	favors Divisia M3	(−3.9)
J-test	favors Divisia M3	(3.2; .9)
JA-test	indeterminate	(1.1; −.82)
Part 2: four lags of dependent variable included		
M2 vs. Divisia M2		
AIC	favors Divisia M2	(−6.6)
J-test	inconclusive	(4.4; 3.3)
JA-test	indeterminate	(−1.5; −.07)
M3 vs. Divisia M3		
AIC	favors	(−5.6)
J-test	Divisia M3	(3.5; 1.1)
JA-test	indeterminate	(.94; −.53)

Part 3: F-tests on exclusion of money from St. Louis Equation

		probability
M2	$F(5,43)$	= 0.99 [0.430]
M3	"	= 0.82 [0.540]
Divisia M2	"	= 3.46 [0.010]
Divisia M3	"	= 2.84 [0.027]

Note: Data period is 1974:2–1989:4.

Canada

The Canadian results (Table 6) confirm the general pattern established above. M1 has a marginal edge over Divisia M1 (in the presence of lagged GNP, but not otherwise) but for broader aggregates the Divisia measure dominates where any discrimination is possible. Divisia L sweeps the board with its simple-sum equivalent and both Divisia M2 and Divisia M3 exhibit obvious domination. The F-tests confirm this general story. Simple-sum M1 has the greatest informational content, but it is closely followed by Divisia M1. Simple-sum M2, M3 and L do not have significant informational content at the 5 percent level, though all of their Divisia equivalents do so.

Japan

Japan does not fit in at all with the pattern of all the other countries in the sample (Table 7). On the basis of the Akaike Information Criterion, all of the simple-sum aggregates marginally dominate their Divisia counterparts. However, none of the J- or JA-tests are able to discriminate and the F-tests make it clear than none of the money measures has any explanatory power at all. In this context it makes no sense to try to distinguish between sets of numbers, none of which matter.

Japan's monetary aggregates differ from many others at the M2 and M3 level, because they include negotiable CDs. However, this would not

Table 4

St. Louis Equations for Germany: Simple-Sum vs. Weighted Money

Dependent variable: first difference of the natural log of nominal GDP.
Independent control variable: first difference of the natural log of government spending.

Part 1: no lagged dependent variable included in regression		
M2 vs. Divisia M2		
AIC	favors Divisia M2	(−.85)
J−test	indeterminate	(1.84; 1.54)
JA−test	indeterminate	(.25; .93)
M3 vs. Divisia M3		
AIC	favors M3	(1.3)
J−test	indeterminate	(.57; 1.73)
JA−test	indeterminate	(−.06; .92)
Part 2: four lags of dependent variable included		
M2 vs. Divisia M2		
AIC	favors Divisia M2	(−1.8)
J−test	favors Divisia M2	(2.9; 1.89)
JA−test	indeterminate	(−.36; −.014)
M3 vs. Divisia M3		
AIC	favors Divisia M3	(−1.17)
J−test	indeterminate	(1.88; 1.12)
JA−test	indeterminate	(.91; .24)

Part 3: F-tests on exclusion of money from St. Louis Equation

		probability
M2	F(5,41)	= 0.71 [0.620]
M3	"	= 1.66 [0.167]
Divisia M2	"	= 1.77 [0.140]
Divisia M3	"	= 2.08 [0.087]

Note: Data period is 1975:1–1990:1.

explain the poor performance of M1. Also, this should give an advantage to Divisia M2 and Divisia M3 which is not supported by the data. Either the Japanese economy behaves very differently from the others studied or there are serious data errors underlying this evidence.

We now turn to tests of the causal links between money and real activity using modern time-series methods.

TIME SERIES TESTS OF MONEY/REAL ACTIVITY CAUSALITY

In this part of the paper, we consider Granger causality tests for a selection of Divisia and simple-sum money aggregates for each of the countries referred to in our St. Louis tests. The causality tests are based on vectors consisting of real GDP, the GDP deflator, a Treasury bill rate and the relevant measure of the money supply. Defining our causality vectors in this way facilitates separate modelling of the effect that different monetary impulses may have (particularly in the short run) on the real and price components of GDP. The Treasury bill rate is also included in the vector because of the well-known spurious effect money can have on output if an interest rate effect is excluded (Sims, 1980). Our causality tests have a number of other features, some of which are novel to this paper.

First, for reasons which are now widely accepted, it is extremely important that the variables entering the causality vector should be stationary and that any indication of cointegratability should be determined (see, Engle and Granger, 1987; MacDonald and Kearney, 1987). The latter aspect of the time-series properties of

Table 5

St. Louis Equations for Switzerland: Simple-Sum vs. Weighted Money

Dependent variable: first difference of the natural log of nominal GDP.
Independent control variable: first difference of the natural log of government spending.

Part 1: no lagged dependent variable included in regression		
M1 vs. Divisia M1		
AIC	favors Divisia M1	(−.064)
J-test	indeterminate	(1.37; −1.31)
JA-test	indeterminate	(1.35; −1.33)
M2 vs. Divisia M2		
AIC	favors Divisia M2	(−1.84)
J-test	inconclusive	(2.99; 2.76)
JA-test	indeterminate	(−.6; .76)
Part 2: four lags of dependent variable included		
M1 vs. Divisia M1		
AIC	favors Divisia M1	(−.05)
J-test	indeterminate	(.93; −.87)
JA-test	indeterminate	(.91; −.88)
M2 vs. Divisia M2		
AIC	favors Divisia M2	(−4.026)
J-test	favors Divisia M2	(3.1; 1.5)
JA-test	indeterminate	(.35; −.27)

Part 3: F-tests on exclusion of money From St. Louis Equation

		probability
M1	F(5,39)	= 2.9 [0.026]
M2	"	= 0.41 [0.840]
Divisia M1	"	= 2.92 [0.025]
Divisia M2	"	= 2.11 [0.085]

Note: Data period is 1975:2–1989:4.

the vector is important, since if there is one (or more) cointegrating relationships among the vector, then it is inappropriate to test for causality among a vector of first-differenced variables, because the Granger representation theorem asserts that such a vector will be misspecified; it will exclude important "long-run" information contained in the levels of the variables. (This was a point recognized by Friedman and Kuttner, 1992, in their causality tests on U.S. data [see their footnote 19], but they did not include such long-run elements in their testing framework.) A second important aspect of any causality test is that it should be robust to non-normal errors. Holmes and Hutton (1992) suggest handling this issue using a non-parametric rank F-test (instead of the standard F-test used in conventional causality studies). In this paper, we argue that since most departures from normality arise from heteroskedasticity, this issue may be dealt with using the Hansen-White non-parametric correction for heteroskedasticity.

The general class of causality tests employed in this section of the paper have come in for some criticism in the literature (see: Zellner, 1979, 1988; Basmann, 1963; and Cooley and LeRoy, 1985). In particular, it is argued that to be interpreted as indicating causality from, say, money to output, Granger-type causality tests have to be embedded in a structural setting and appropriate identifying restrictions imposed (see Holmes and Hutton, 1992, for a partial rebuttal). However, given our purpose is not to examine causality for a single measure of money, but rather to determine which measures from a range of simple-sum and Divisia money magnitudes have the greatest informational content,

Table 6

St. Louis Equations for Canada: Simple-Sum vs. Weighted Money

Dependent variable: first difference of the natural log of nominal GNP.
Independent control variable: first difference of the natural log of government spending.

Part 1: no lagged dependent variable included in regression

Divisia M1 vs. M1		
AIC	favors Divisia M1	(.34)
J-test	indeterminate	(.45; .78)
JA-test	indeterminate	(.09; .46)
Divisia M2 vs. M2		
AIC	favors Divisia M2	(6.0)
J-test	favors Divisia M2	(1.7; 4.8)
JA-test	favors Divisia M2	(−.84; 2.5)
Divisia M3 vs. M3		
AIC	favors Divisia M3	(3.67)
J-test	favors Divisia M3	(1.29; 3.5)
JA-test	favors Divisia M3	(−.39; 2.4)
Divisia L vs. L		
AIC	favors Divisia L	(8.43)
J-test	favors Divisia L	(−.43; 4.3)
JA-test	favors Divisia L	(−.99; 3.72)

Part 2: four lags of dependent variable included

Divisia M1 vs. M1		
AIC	favors M1	(−.19)
J-test	indeterminate	(.81; .56)
JA-test	indeterminate	(.44; .25)
Divisia M2 vs. M2		
AIC	favors Divisia M2	(3.34)
J-test	favors Divisia M2	(1.26; 3.3)
JA-test	indeterminate	(−.8; 1.04)
Divisia M3 vs. M3		
AIC	favors Divisia M3	(2.87)
J-test	favors Divisia M3	(.55; 2.71)
JA-test	indeterminate	(−.74; 1.53)
Divisia L vs. L		
AIC	favors Divisia L	(3.49)
J-test	favors Divisia L	(.49; 2.8)
JA-test	favors Divisia L	(−.49; 2.17)

Part 3: F-tests on exclusion of money from St. Louis Equation

		probability
M1	F(5,55)	= 7.05 [0.000]
M2	"	= 2.03 [0.088]
M3	"	= 1.37 [0.250]
L	"	= 1.25 [0.299]
Divisia M1	"	= 6.95 [0.000]
Divisia M2	"	= 3.34 [0.010]
Divisia M3	"	= 2.43 [0.047]
Divisia L	"	= 2.53 [0.039]

Note: Data period is 1968:3–1987:1.

Table 7

St. Louis Equations for Japan: Simple-Sum vs. Weighted Money

Dependent variable: first difference of the natural log of nominal GNP.
Independent control variable: first difference of the natural log of nominal government spending.

Part 1: no lagged dependent variable included in regression

M1 vs. Divisia M1		
AIC	favors M1	(.32)
J-test	indeterminate	(−1.57; 1.86)
JA-test	indeterminate	(−1.7; 1.72)
M2 vs. Divisia M2		
AIC	favors M2	(.5)
J-test	indeterminate	(−.7; 1.45)
JA-test	indeterminate	(−1.09; 1.05)
M3 vs. Divisia M3		
AIC	favors M3	(.72)
J-test	indeterminate	(−.62; 1.53)
JA-test	indeterminate	(−1.01; 1.17)

Part 2: four lags of dependent variable included

M1 vs. Divisia M1		
AIC	favors M1	(.503)
J-test	inconclusive	(−1.96; 2.23)
JA-test	inconclusive	(−2.03; 2.16)
M2 vs. Divisia M2		
AIC	favors M2	(.44)
J-test	indeterminate	(−.45; 1.49)
JA-test	indeterminate	(−1.19; .72)
M3 vs. Divisia M3		
AIC	favors M3	(.77)
J-test	indeterminate	(−.64; 1.56)
JA-test	indeterminate	(−1.08; 1.15)

Part 3: F-tests for exclusion of money from St. Louis Equation

		probability
M1	F(5,42)	= .79 [0.559]
M2	"	= .24 [0.942]
M3	"	= .38 [0.861]
Divisia M1	"	= .63 [0.675]
Divisia M2	"	= .11 [0.990]
Divisia M3	"	= .14 [0.981]

Note: Data period is 1976:1–1991:2.

we do not believe that the standard criticisms of our framework have as much import as they may have for more conventional studies. We also take encouragement from the fact that even in recent papers which only address the causality properties of a single money measure (see, for example, Friedman and Kuttner, 1993), Granger-type tests have still been employed (although, we would argue, incorrectly since such tests only involve a vector of differenced variables).

Unit Root And Multivarite Cointegrtion Results

We begin the empirical analyses of this section by testing for unit roots in the variables entering our causality vector. Although the cointegration method we employ below is due to Johansen and is, therefore, a multivariate test for the number of unit roots in a given vector, we nevertheless thought it worthwhile to examine some simple univariate unit root rests for motivational purposes, and also to guide us in the appropriate order of differencing for the variables entering the cointegrating tests.

There have been, in fact, a variety of proposed methods for implementing univariate unit roots tests (for example, Dickey and Fuller, 1979; Phillips and Perron, 1988; Stock, 1990; and Park and Choi, 1988) and each has been used in the applied macroeconomics literature. Since, however, there is now a growing consensus that the earliest, unit root test—due to Dickey and Fuller (1979)—has superior small sample properties compared to its competitors (see Campbell and Perron, 1991, for a discussion), we employ it. In particular, we estimate the following regression equation for the series entering our causality vector:

$$(1)\ \Delta x_t = \mu + \beta\tau + \pi x_{t-1} + \sum_{i=1}^{q} \gamma_i \Delta x_{t-i} + u_t,$$

where x is the variable of interest, μ and τ denote deterministic regressors (a constant and a time trend, respectively). Equation 1 represents a reparameterization of an autoregression of x_t in levels, where the length of the autoregression is set to ensure that u_t is serially uncorrelated. In this context, a test for a unit root in the series x_t amounts to a t-test of $\pi = 0$ (that is, the sum of the autoregressive parameters in the levels autoregression is unity). The alternative hypothesis of stationarity requires that π be significantly negative. Since under the null hypothesis of non-stationarity the calculated t-ratio will not have a student's t-distribution, critical values calculated by Fuller (1976) must be used instead.

In estimating equation 1 for so many country/variable combinations, we initially used a common lag length, q, of 4 for all variables. However, given the sensitivity of Augmented Dickey-Fuller (ADF) tests to the chosen lag length we also experimented with shorter lag lengths in instances where the estimated t-ratio on π was close to its critical value, this being particularly so when a variable appeared to be I(2). (In particular, and following the recommendation of Hall, forthcoming, and Campbell and Perron, 1991, we sequentially deleted insignificant lags of the dependent variable until we arrived at a parsimonious relationship which satisfied the non-autocorrelation criterion.) In the reported tables that follow, a shorter lag length than 4 is denoted by the number in parenthesis after the variable mnemonic. Where the default value of 4 is reported for the ADF statistic, it means that either all four lags are significant or, in instances where some lags are insignificant, reducing the lag length from 4 would not have made a qualitative difference to the interpretation.

In Tables 8 through 14, we present our estimates of the t-ratio for the estimated coefficient π in equation 1 for the levels and first and second differences of each series in question. This procedure facilitates a test for one and two unit roots, respectively. The t-ratio has been calculated with the time trend included in the regression equation, as in equation 1 (referred to as t_τ), and the trend excluded (referred to as t_μ). This follows the sequential testing strategy recommended by, for example, Perron (1988): If a deterministic component is excluded from a unit root test but such a component features in the data generation process (DGP) of the series, the resulting test will have low power. However, if the deterministic component is absent from the DGP, greater power may be obtained by estimating p without the trend component. In our unit root tests, all variables, apart from the interest rate series, have been transformed into natural logarithms. In order to capture any remaining seasonality in the variables, three seasonal dummies have been incorporated into our estimated version of equation 1.

A number of findings emerge from Tables 8 to 14. First, there are only two variables which appear to be stationary around a deterministic trend, namely the Australian Treasury bill rate and the Rotemberg Currency Equivalent measure —all the other variables appear to contain stochastic trends. As is common in many other studies of the time series properties of macroeconomic series, the level of the price deflator for a number of countries appears to be an I(2) process; that is, inflation in these countries is an I(1) process. Interestingly, it is also the case that some of our monetary series appear to be I(2) processes. In general we found that this result (but not the result for the deflator) was particularly sensitive to the lag length specified in the estimated equation.

For example, in the case of the United States, all of the simple-sum money measures appeared to be I(2) when q was set equal to 4 (DM1A and DM1 also appeared I(2) with four lags). However, in these instances it appeared that this lag length resulted in an overparameterized regression equation and the deletion of a single lag

Table 8
Unit Root Tests for the United States

	L		Δ		Δ^2	
	t_μ	t_τ	t_μ	t_τ	t_μ	t_τ
SSM1	−1.61	−2.08	−3.80	−4.35	−9.18	−9.16
DM1	−1.97	−2.16	−3.61	−4.34	−8.38	−8.35
SSM1A	0.03	−2.70	−3.61	−3.61	−9.29	−9.29
DM1A	0.77	−2.05	−4.13	−4.21	−9.52	−9.49
SSM2	1.40	−0.23	−3.20	−3.47	−8.37	−8.37
DM2	0.80	−1.78	−4.19	−4.22	−8.21	−8.19
SSM3 (1)	1.66	0.44	−2.93	−3.36	−9.14	−9.14
DM3	1.17	−1.27	−3.93	−4.06	−7.79	−7.79
SSL	1.40	−0.61	−1.73	−2.01	−7.05	−7.12
DL	0.95	−1.66	−3.68	−3.74	−7.81	−7.80
GDP	−1.73	−2.73	−4.51	−4.71	−7.69	−7.66
DEF	−1.01	−1.94	−1.74	−1.59	−6.52	−6.10
TB	−2.31	−2.03	−5.49	−5.64	−11.84	−11.78
RCE	−1.31	−3.70	−4.73	−4.76	−5.16	−5.14
BCE	0.67	−2.59	−3.58	−3.68	−6.38	−6.36

Note: Unless otherwise noted, each ADF statistic was computed with a lag of 3. SS denotes a simple-sum monetary aggregate; D denotes a Divisia aggregate; M denotes money; L denotes liquidity; GDP denotes real Gross Domestic Product; DEF denotes the GDP deflator; and TB denotes a Treasury bill rate. L, Δ and Δ^2 denote, respectively, the level and first and second difference of a variable. t_μ and t_τ are augmented Dickey Fuller statistics with allowance for a constant mean and for a trend in mean, respectively. The 5 percent critical values for t_μ and t_τ are −2.89 and −3.43, respectively (Fuller, 1976).

Table 9
Unit Root Tests for the United Kingdom

	L		Δ		Δ^2	
	t_μ	t_τ	t_μ	t_τ	t_μ	t_τ
SSM4 (2)	−0.44	−1.60	−3.07	−3.06	−7.39	−7.35
DM4 (1)	−0.72	−1.22	−3.64	−3.64	−10.42	−10.36
GDP	−1.06	−1.92	−3.81	−3.85	−8.22	−8.18
DEF	−2.07	−0.66	−2.71	−3.35	−5.02	−5.07
TB	−2.78	−3.12	−5.26	−5.25	−8.07	−8.03

Note: See Table 8.

Table 10

Unit Root Tests for Australia

	L		Δ		Δ^2	
	t_μ	t_τ	t_μ	t_τ	t_μ	t_τ
SSM2	0.97	−2.44	−3.21	−3.30	−4.76	−4.73
DM2	0.28	−1.73	−3.02	−3.02	−5.45	−5.40
SSM3 (2)	2.55	−0.26	−3.18	−4.24	−4.56	−4.49
DM3 (2)	2.39	−0.43	−3.01	−3.88	−5.17	−5.15
GDP	−0.22	−2.48	−3.68	−3.64	−5.07	−4.97
DEF	−1.15	−1.19	−3.34	−3.46	−4.24	−4.41
TB	−1.73	3.46	−3.33	−3.31	−5.17	−5.12

Note: See Table 8.

Table 11

Unit Root Tests for Germany

	L		Δ		Δ^2	
	t_μ	t_τ	t_μ	t_τ	t_μ	t_τ
SSM2 (1)	−0.75	−1.72	−3.11	−2.97	−9.38	−9.43
DM2 (1)	−0.45	−1.97	−3.74	−3.69	−8.27	−8.20
SSM3 (2)	−2.02	−2.72	−2.96	−3.23	−6.81	−6.75
DM3 (1)	−1.01	−2.62	−3.78	−3.84	−7.65	−7.57
GDP (1)	0.24	−1.08	−6.23	−6.21	−11.18	−11.08
DEF (2)	−1.99	−0.92	−2.76	−3.21	−7.24	−7.17
TB (2)	−1.99	−1.97	−3.63	−3.58	−6.98	−6.93

Note: See Table 8.

Table 12

Unit Root Tests for Switzerland

	L		Δ		Δ^2	
	t_μ	t_τ	t_μ	t_τ	t_μ	t_τ
SSM1	−1.17	−2.32	−3.43	−3.40	−5.11	−5.07
DM1	−1.18	−2.35	−3.44	−3.40	−5.10	−5.06
SSM2 (1)	0.15	−1.44	−3.30	−3.31	−7.16	−7.07
DM2 (1)	−1.19	−1.91	−3.19	−3.18	−7.25	−7.22
GDP	0.95	−1.57	−2.10	−2.78	−4.81	−4.75
DEF	−1.06	−0.94	−2.22	−2.03	−4.76	−4.87
TB	−1.76	−1.99	−3.03	−2.99	−5.84	−5.81

Note: See Table 8.

Table 13

Unit Root Tests for Canada

	L		Δ		Δ^2	
	t_μ	t_τ	t_μ	t_τ	t_μ	t_τ
SSM1	−2.64	−1.21	−3.02	−3.73	−5.77	−5.72
SSM2	−1.65	−1.15	−2.21	−2.61	−4.85	−4.86
SSM3	−2.04	−0.70	−1.72	−2.37	−5.67	−5.66
SSL	−1.80	1.48	0.32	−0.36	−1.99	−2.38
DM1	−2.72	−1.18	−2.93	−3.66	−5.23	−5.18
DM2	−2.06	−0.74	−2.68	−3.21	−5.44	−5.45
DM3	−2.63	−1.40	−2.25	−3.20	−5.47	−5.52
DL	−2.27	−0.79	−2.53	−3.26	−5.06	−5.12
GDP	−1.28	−1.87	−2.99	−3.11	−5.72	−5.66
DEF	−1.23	−2.21	−1.79	−1.94	−4.13	−4.18
TB	−1.44	−1.36	−3.24	−3.26	−5.86	−5.81

Note: See Table 8.

Table 14

Unit Root Tests for Japan

	L		Δ		Δ^2	
	t_μ	t_τ	t_μ	t_τ	t_μ	t_τ
SSM1	−1.18	−2.78	−3.08	−3.19	−4.72	−4.67
DM1	−1.19	−2.74	−3.01	−3.13	−4.64	−4.60
SSM2	−1.14	−2.31	−2.55	−2.65	−3.26	−3.19
DM2	−0.85	−2.31	−2.08	−1.96	−3.52	−3.53
SSM3	−2.11	−2.22	−2.44	−2.41	−2.69	−2.59
DM3	−1.34	−2.58	−1.70	−1.92	−3.28	−3.28
GNP (1)	0.38	−1.16	−5.15	−5.12	−9.41	−9.29
DEF	−2.07	−2.47	−2.45	−2.35	−4.87	−5.10
TB	−2.23	−3.36	−3.90	−3.64	−2.83	−2.71

Note: See Table 8.

made a dramatic difference to the estimated t-ratio on π (without significantly affecting the non-autocorrelatedness properties of the residuals). Indeed, with three lags all of the money measures with the exception of simple-sum M3 (SSM3) and simple-sum L (SSL) appear to be I(1); the former variable appears I(1) when $q=1$, while SSL appears I(2) at all lag lengths (again, the residuals in each of these cases were non-autocorrelated).

The country with the greatest preponderence of monetary aggregates being I(2) is Canada, in which six out of the eight chosen monetary aggregates appear to have two unit roots. The finding that the level of a country's price series is an I(2) process finds confirmation in a number of other empirical studies (see, for example, Johansen and Juselius, 1990). Furthermore, the finding that monetary aggregates are I(2) has also been reported by other researchers (Rasche, 1993), although this finding does not appear to be as robust as that for price deflators.

We now turn to an analysis of the cointegration properties of a vector of variables for each of our chosen countries. In particular, for each country we use the methods of Johansen (1988, 1991) to estimate the number of cointegrating vectors in $y' = [\chi m, gdp, def, tb]$, where m denotes the money supply, χ is either ss (for simple-sum) or d (for Divisia), gdp is real output, def is the deflator corresponding to output, and tb denotes the relevant interest rate (usually a Treasury bill rate). The fact that the variables entering y' may for any one country be a mix of I(1) and I(2) processes has to be taken into account in our implementation of the Johansen procedure, since the latter is only appropriate for I(1) variables and driftless I(0) variables. We therefore use the information from our unit root tests to reduce the order of integration of any I(2) variables to I(1), by entering the first difference of the level of such a variable. Thus, if a country's price level is I(1), we enter the change in the price level (equivalent to the inflation rate, since the price level is transformed logarithmically) and/or if the money measure is also I(2), it is also entered in differences.

In the context of estimating a conventional money demand function (which has the same set of variables as are contained in our y vector), Johansen (1991) has suggested dealing with the two unit roots in m and p by respecifying the y vector to consist of $(m\text{-}p)$, y, i and Δp. However, given the nature of the current exercise, and also since, in many instances it is only p that appears to be I(2), we do not believe that such a specification is as attractive as the one adopted here. To determine the number of unit roots in y' we use the following method, due to Johansen (1988, 1991). This method may be thought of as the multivariate equivalent of (1). It is assumed that y_t has the following autoregressive representation with Gaussian errors ε_t:

$$(2)\ y_t = \Pi_1 y_{t-1} + \Pi_2 y_{t-2} + \ldots + \Pi_k y_{t-k} + \varepsilon_t,\quad t = 1,2, \ldots, T.$$

Equation 2 may be reparameterized as

$$(2')\ \Delta y_t = \mu + \Pi y_{t-k} + \sum_{i=1}^{q} \Gamma_i \Delta y_{t-i} + u_t,$$

where $q = k-1$, $\Pi = \sum_{j=1}^{k} B_i - I$, B_j is an (n x n) matrix from the lag polynomial in the (levels) VAR and $\Gamma_i = -\sum_{j=i+1}^{k} B_j$ for $i=1,\ldots q$. The key difference between 1 and 2 is that in 2 there is no allowance for a deterministic trend (or that the series are driftless). The long-run static equilibrium corresponding to 2 is[1]

$$(3)\ \Pi\chi = 0.$$

The matrix Π is the multivariate analogue of π in equation 1. Assuming that the variables entering the y vector do not have an order of integration greater than 1, then the right-hand side of equation 2 can only be stationary if the components of Πy_{t-k} are stationary. This, in turn, may be determined by the rank, r, of the matrix Π, and, in particular, whether $0 \leq r \leq n$, where n denotes the number of variables in y. If $r=n$ (that is, Π has full rank) then Πy_{t-k} can only be stationary if all n linearly independent combinations of y_{t-k} formed using Π are stationary: A standard VAR analysis in levels is appropriate here. If, at the other extreme, $r=0$ (and $\Pi=0$) then there are no linear combinations in y_t which are stationary, and (2) therefore becomes a VAR in first differences (this is the kind of VAR specification used in the

[1]Dynamic steady-state equilibrium simply involves the addition of a term in the constant vector of steady-state growth rates to equation 2, which we omit here for expositional purposes; this does not affect the subsequent discussion.

majority of traditional Granger causality tests). If, however $0<r<n$, Π will be of reduced rank and there must exist (n x r) matrices α and β such that $\Pi = \alpha\beta'$, and for Πy_{t-k} to be stationary $\beta' y_{t-k}$ must be stationary. The β matrix therefore contains the cointegrating vectors and α represents the matrix of adjustment vectors. For example, if β'_i is the ith row of β' then:

(4) $\beta'_i y_t \sim I(0)$.

Johansen (1988, 1991) has proposed a maximum likelihood method of estimating all of the cointegrating vectors contained in Π and significance tests to determine how many of the vectors are statistically significant. Since the Johansen technique is now well-known, we do not present it here. Instead, we simply note the two test statistics used to determine the number of significant cointegrating vectors.

In our application the likelihood ratio, or trace, test statistic (LR1), for the hypothesis that there are at most r distinct cointegrating vectors, is

(5) $LR1 = T \sum_{i=r+1}^{n} ln(1-\lambda_i)$,

where $\lambda_{r+1},\ldots,\lambda_n$ are the $n - r$ smallest squared canonical correlations between the y_{t-k} and Δy, corrected for the effect of the lagged differences of the y_t process (for details of how to extract the λ_i's, see Johansen 1988). Additionally, the likelihood ratio statistic for testing at most r cointegrating vectors against the alternative of $r+1$ cointegrating vectors is given by equation 4

(6) $LR2 = Tln(1-\lambda_{r+1})$.

Johansen (1988) shows that equations 5 and 6 have a non-standard distribution under the null hypothesis. He does, however, provide approximate critical values for the statistic, generated by Monte Carlo methods. (The critical values recorded in Johansen's 1988 paper are for a VAR without an intercept term or seasonal dummies. Since these were included in our empirical analysis, we used the critical values for 5 and 6 reported in Johansen and Juselius, 1990.)

In Table 15, our estimated values of LR1 and LR2 are presented, and the critical values and relevant null hypothesis are reported at the bottom of the table. Consider first the results for the United States. Interestingly, there is no evidence of cointegration for any of the narrow monetary measures (i.e. M1 and M1A). However, with the exception of SSM3, there is clear evidence of one unique cointegrating vector for all monetary measures which are broader than M1. It follows from this that it is the introduction of these broader monetary measures that produces a cointegrating set (and not the income, interest rate or inflation rate). Since the Rotemberg currency equivalent measure appears to be stationary around a deterministic trend, it would appear not to be an ideal candidate for the Johansen methodology. However, for completeness, and also since it is often difficult to discriminate between a variable which is stationary around a trend and one which has a stochastic unit root, we also test for the numbers of cointegrating vectors in a y vector defined for RCE. Interestingly, this also gives strong evidence of one cointegrating vector, as does the BCE measure. (BCE is a variety of currency equivalence which uses Divisia weights.) The evidence for other (non-U.S.) countries in Table 15 is also suggestive of there being long-run relationships contained in different specifications of the y' vectors: The vast majority of monetary measures produce at least one cointegrating vector and many produce two. Again, there does not appear to be any split between Divisia and simple-sum monetary measures in terms of the production of cointegrating relationships.

The broad picture to emerge from Table 15 is that there is strong evidence of at least one cointegrating vector for most country/money combinations. It also seems that, at least in this long-run modelling context, there is no sharp distinction between Divisia and simple-sum money. It may be, however, that one or other monetary measures produce more "sensible" estimates of the cointegrating vector and we return to this point in a later section (where we also examine sample specific issues which may be important for the United States). However, for the implementation of our causality tests, the main implication to be drawn from Table 15 is that a causality relationship specified simply in differences will be misspecified for the vast majority of country/money combinations. We therefore propose estimating the vector error correction models implied by our cointegration results and subjecting them to exclusion tests on the lags of each of the differenced (either first or second differenced, depending on the outcome of the results reported in Tables 8 to 14) and also on the lagged cointegrating terms. Since we correct the coefficient variance-covariance matrix for heteroskedasticity (using the methods of Hansen, 1980; and White, 1978), the exclusion tests are performed using linear Wald statistics,

Table 15

Estimated Trace and λMax Statistics

United States

Trace (LR1)

SSM1	DM1	SSM1A	DM1A	SSM2	DM2	SSM3	DM3	SSL	DL
0.02	0.10	0.07	0.14	3.80	5.13	3.45	5.08	2.31	4.77
5.19	0.07	7.66	7.73	10.38	12.80	8.14	11.59	8.05	10.99
18.55	18.05	17.83	18.69	23.34	23.34	20.54	21.91	20.65	21.53
40.17	38.13	33.73	40.25	57.92	58.85	47.67	52.35	54.99	53.27

United States

λMAX (LR2)

SSM1	DM1	SSM1A	DM1A	SSM2	DM2	SSM3	DM3	SSL	DL
0.02	0.01	0.07	0.14	3.80	5.13	3.45	5.08	2.31	4.77
5.18	5.06	7.59	7.58	6.58	7.66	4.66	6.51	5.73	6.22
13.35	12.88	10.16	10.97	12.94	10.63	12.39	10.32	12.60	10.53
21.61	20.08	15.90	21.56	34.58	35.41	27.13	30.44	34.34	31.74

United Kingdom

Trace (LR1)		λMax (LR2)	
SSM4	DM4	SSM4	DM4
1.89	3.85	1.89	3.85
10.20	12.17	8.31	8.32
38.34	37.53	28.13	25.36
88.45	64.20	50.12	26.67

Table 15 (continued)

Estimated Trace and λMax Statistics

Australia

Trace (LR1)				λMax (LR2)			
SSM2	DM2	SSM3	DM3	SSM2	DM2	SSM3	DM3
0.01	*0.75*	*0.61*	*0.12*	0.01	0.74	0.06	0.12
10.51	5.74	10.77	6.23	10.50	4.99	10.71	6.12
21.89	*26.93*	*31.97*	*23.12*	11.38	21.18	21.19	16.88
53.96	55.67	67.61	56.41	32.07	28.74	35.64	33.79

Germany

Trace (LR1)				λMax (LR2)			
SSM2	DM2	SSM3	DM3	SSM2	DM2	SSM3	DM3
0.02	0.28	0.81	0.68	0.01	0.03	0.81	0.68
11.11	12.62	17.08	18.44	11.10	12.34	16.26	17.76
29.62	39.21	40.02	43.56	18.51	26.58	22.94	25.11
63.38	77.27	70.38	81.55	33.75	38.06	30.37	37.98

Switzerland

Trace (LR1)				λMax (LR2)			
SSM1	DM1	SSM2	DM2	SSM1	DM1	SSM2	DM2
0.59	0.60	0.49	1.53	0.59	0.60	0.49	1.53
15.54	*15.50*	*12.41*	*13.29*	14.93	14.89	11.91	11.76
35.55	35.57	33.91	33.71	20.01	20.07	21.49	20.41
56.74	*57.08*	*64.82*	*60.78*	*21.18*	21.51	35.91	27.08

Table 15 (continued)
Estimated Trace and λMax Statistics

Canada

Trace (LR1)				λMax (LR2)			
SSM1	**DM1**	**SSM2**	**DM2**	**SSM1**	**DM1**	**SSM2**	**DM2**
2.35	2.67	0.77	0.16	2.35	2.67	0.77	0.16
15.06	15.00	8.28	6.66	12.71	12.33	7.51	6.50
41.85	43.42	21.36	17.74	26.79	28.41	13.07	11.08
79.71	81.55	53.38	55.68	37.86	38.13	32.03	37.95

Japan

Trace (LR1)						λMax (LR2)					
SSM1	**DM1**	**SSM2**	**DM2**	**SSM3**	**DM3**	**SSM1**	**DM1**	**SSM2**	**DM2**	**SSM3**	**DM3**
3.09	30.08	2.42	0.62	3.46	3.03	3.04	3.08	2.42	2.62	3.46	3.03
12.74	12.97	16.28	15.03	16.91	15.41	9.64	9.89	13.85	12.41	13.45	12.37
32.26	32.19	38.76	34.97	39.39	35.25	19.51	19.21	22.47	19.95	22.48	19.83
65.14	67.00	71.17	69.63	67.29	64.82	32.88	34.81	32.41	34.65	27.90	29.56

Null hypotheses and 5 percent critical values for Trace and λMax statistics.

Trace		λMax	
Null Hypothesis	5% Critical Value	Null Hypothesis	5% Critical Value
$r<3$	8.18	$r=3 \mid r=4$	8.18
$r<2$	17.95	$r=2 \mid r=3$	14.90
$r<1$	31.53	$r=1 \mid r=2$	21.07
$r=0$	48.28	$r=0 \mid r=1$	27.14

Note: Variables are defined in Table 8. The Trace and λMax statistics are defined in the text.

which have a central chi-squared distribution.

Causality Tests

The exclusion tests for each country are reported in Tables 16 through 22. Consider first the results for the United States, reported in Table 16. Since there is some ambiguity regarding the stochastic properties of the Rotemberg currency equivalent measure (see discussion above), we present two systems for this variable: one in which the variable enters as a level and a deterministic time trend is included in each equation of the system (the system with RCE1), and one in which it enters as a first difference and the ECM term from the Johansen estimates reported in Table 15 is also included in each equation of the system (the system with RCE2).

In terms of the U.S.' real output relationship, there is a very clear, significant, short-run influence of the Treasury bill rate. This influence is repeated in all of the other equations as well, (apart from the deflator equation when SSM1 and DM1 are used). This confirms the findings of much other research on the importance of including an interest rate in the causality specification (see: Sims, 1980; and Friedman and Kuttner, 1993). In equations in which an ECM term appears, the majority of significant impacts tend to occur in equations which feature the deflator or money (Divisia or simple sum) as the dependent variable. What then of the potential short-run differential impact of simple-sum and Divisia money? Interestingly, and in contrast to our initial discussion of the long-run impact,

Table 16

Causality Tests for the United States

	SSM1	GDP	DEF	TB
SSM1	87.21 (0.00)	4.19 (0.38)	4.22 (0.38)	17.43 (0.00)
GDP	1.22 (0.87)	28.67 (0.00)	4.63 (0.33)	10.61 (0.03)
DEF	2.85 (0.58)	5.55 (0.23)	56.56 (0.00)	13.44 (0.00)
TB	4.00 (0.00)	27.45 (0.00)	6.28 (0.18)	19.59 (0.00)
	DM1	**GDP**	**DEF**	**TB**
DM1	37.88 (0.00)	5.38 (0.25)	5.04 (0.28)	5.66 (0.23)
GDP	0.17 (0.99)	28.08 (0.00)	4.53 (0.34)	10.85 (0.03)
DEF	1.39 (0.84)	5.86 (0.21)	52.46 (0.00)	11.85 (0.02)
TB	17.32 (0.00)	28.33 (0.00)	6.81 (0.15)	10.01 (0.04)
	SSM1A	**GDP**	**DEF**	**TB**
SSM1A	68.74 (0.00)	1.07 (0.89)	12.78 (0.01)	40.14 (0.00)
GDP	2.73 (0.60)	22.40 (0.00)	2.37 (0.00)	11.39 (0.02)
DEF	4.90 (0.29)	5.16 (0.27)	64.57 (0.00)	10.51 (0.03)
TB	21.86 (0.00)	21.22 (0.00)	9.45 (0.05)	24.78 (0.00)
	DM1A	**GDP**	**DEF**	**TB**
DM1A	57.30 (0.00)	1.12 (0.89)	12.54 (0.01)	17.12 (0.00)
GDP	3.45 (0.48)	26.46 (0.00)	3.30 (0.51)	13.79 (0.00)
DEF	3.77 (0.44)	5.59 (0.23)	61.65 (0.00)	12.39 (0.01)
TB	16.81 (0.00)	21.17 (0.00)	9.29 (0.05)	23.56 (0.00)
	SSM2	**GDP**	**DEF**	**TB**
SSM2	48.63 (0.00)	7.34 (0.12)	4.82 (0.31)	6.75 (0.15)
GDP	13.67 (0.00)	9.73 (0.04)	1.50 (0.83)	7.53 (0.11)
DEF	20.93 (0.00)	8.51 (0.07)	23.76 (0.00)	14.57 (0.00)
TB	27.36 (0.00)	13.97 (0.00)	14.23 (0.00)	12.42 (0.01)
ECM	17.23 (0.00)	2.25 (0.13)	8.29 (0.00)	0.60 (0.44)
	DM2	**GDP**	**DEF**	**TB**
DM2	23.71 (0.00)	9.97 (0.04)	10.74 (0.03)	9.23 (0.05)
GDP	10.09 (0.04)	7.78 (0.09)	2.45 (0.65)	18.64 (0.00)
DEF	6.72 (0.15)	6.95 (0.14)	26.71 (0.00)	6.73 (0.15)
TB	95.24 (0.00)	18.35 (0.00)	18.51 (0.00)	14.47 (0.00)
ECM	18.39 (0.00)	4.52 (0.03)	12.19 (0.00)	4.74 (0.03)
	SSM3	**GDP**	**DEF**	**TB**
SSM3	89.12 (0.00)	5.04 (0.28)	8.74 (0.07)	1.04 (0.90)
GDP	11.88 (0.02)	15.23 (0.00)	2.61 (0.63)	9.80 (0.04)
DEF	12.32 (0.02)	6.84 (0.14)	25.13 (0.00)	10.49 (0.03)
TB	10.52 (0.03)	22.28 (0.00)	13.14 (0.01)	9.91 (0.04)
ECM	8.50 (0.00)	0.68 (0.41)	13.25 (0.00)	2.67 (0.10)

Table 16 (continued)

Causality Tests for the United States

	DM3	GDP	DEF	TB
DM3	38.22 (0.00)	8.64 (0.07)	10.82 (0.03)	7.16 (0.13)
GDP	9.20 (0.05)	9.37 (0.05)	3.21 (0.52)	18.27 (0.00)
DEF	6.45 (0.17)	6.58 (0.16)	29.61 (0.00)	6.61 (0.16)
TB	78.27 (0.00)	18.73 (0.00)	18.79 (0.00)	15.62 (0.00)
ECM	14.58 (0.00)	3.02 (0.08)	13.77 (0.00)	5.66 (0.02)
	SSL	**GDP**	**DEF**	**TB**
SSL	92.18 (0.00)	7.16 (0.13)	7.96 (0.09)	2.54 (0.64)
GDP	24.22 (0.00)	15.34 (0.00)	3.17 (0.53)	10.07 (0.04)
DEF	13.82 (0.00)	6.94 (0.14)	16.05 (0.00)	10.64 (0.03)
TB	20.53 (0.00)	27.57 (0.00)	13.11 (0.01)	11.04 (0.03)
ECM	17.05 (0.00)	0.75 (0.38)	13.69 (0.00)	1.17 (0.27)
	DL	**GDP**	**DEF**	**TB**
DL	33.11 (0.00)	12.01 (0.02)	7.79 (0.09)	7.39 (0.12)
GDP	12.87 (0.01)	10.37 (0.03)	2.91 (0.57)	14.26 (0.00)
DEF	6.47 (0.16)	7.07 (0.13)	26.05 (0.00)	7.05 (0.13)
TB	68.23 (0.00)	23.47 (0.00)	16.64 (0.00)	15.57 (0.00)
ECM	14.45 (0.00)	2.76 (0.09)	11.96 (0.00)	3.94 (0.04)
	RCE1	**GDP**	**DEF**	**TB**
RCE1	37.52 (0.00)	11.78 (0.02)	5.27 (0.26)	32.10 (0.00)
GDP	17.22 (0.00)	9.47 (0.05)	0.87 (0.93)	11.08 (0.02)
DEF	3.55 (0.47)	7.18 (0.13)	53.72 (0.00)	6.94 (0.14)
TB	17.83 (0.00)	15.47 (0.00)	4.92 (0.79)	10.16 (0.04)
	RCE2	**GDP**	**DEF**	**TB**
RCE2	26.14 (0.00)	8.57 (0.07)	10.33 (0.04)	28.56 (0.00)
GDP	16.07 (0.00)	13.65 (0.00)	1.69 (0.79)	13.13 (0.01)
DEF	2.86 (0.58)	7.11 (0.13)	42.38 (0.00)	7.11 (0.13)
TB	16.66 (0.00)	16.36 (0.00)	8.02 (0.09)	10.04 (0.04)
ECM	7.64 (0.00)	1.72 (0.18)	4.34 (0.04)	4.74 (0.03)
	BCE	**GDP**	**DEF**	**TB**
BCE	12.78 (0.01)	5.66 (0.23)	5.61 (0.23)	7.02 (0.11)
GDP	7.41 (0.12)	9.83 (0.04)	1.46 (0.83)	20.56 (0.00)
DEF	4.09 (0.39)	6.05 (0.19)	30.72 (0.00)	8.51 (0.07)
TB	62.27 (0.00)	17.52 (0.00)	12.19 (0.02)	12.95 (0.01)
ECM	0.27 (0.60)	4.46 (0.03)	5.79 (0.02)	6.44 (0.01)

Note: The variables are as defined in Table 8. The variable at the column head is the dependent variable. The numbers not in parentheses are linear Wald statistics, while the numbers in parentheses are marginal significance levels.

Table 17
Causality Tests for the United Kingdom

	SSM4	GNP	DEF	TB
SSM4	39.89 (0.00)	0.26 (0.99)	1.90 (0.75)	17.59 (0.00)
GNP	11.20 (0.02)	2.39 (0.66)	9.08 (0.06)	10.22 (0.04)
DEF	28.74 (0.00)	2.79 (0.59)	5.28 (0.26)	3.97 (0.41)
TB	4.44 (0.35)	3.97 (0.41)	11.99 (0.02)	8.66 (0.07)
ECM	4.26 (0.12)	8.46 (0.01)	24.38 (0.00)	10.71 (0.00)
	DM4	**GNP**	**DEF**	**TB**
DM4	15.58 (0.00)	4.88 (0.30)	14.59 (0.00)	13.52 (0.00)
GNP	1.43 (0.84)	1.91 (0.75)	6.18 (0.19)	7.60 (0.11)
DEF	16.30 (0.00)	2.17 (0.70)	12.23 (0.02)	8.15 (0.08)
TB	6.58 (0.16)	3.58 (0.46)	5.74 (0.22)	2.11 (0.72)
ECM	4.54 (0.10)	0.92 (0.63)	27.67 (0.00)	2.03 (0.36)

Note: See Table 16.

there is a clear differential impact. For example, in terms of the output equation, the Divisia monetary measure is significant at the 5 percent level in three cases (namely, DM2, DL and RCE1) and at the 7 percent level in two instances (that of DM3 and RCE1), but none of the simple-sum money terms enters significantly even at the 10 percent level. It is also interesting to note that among the two currency equivalent measures, it is only the RCE measure which features significantly in the real output equation (confirming the significant influence for this monetary measure noted by Belongia, 1993). The significance of these Divisia measures is repeated in the deflator equations (apart from RCE1, although, additionally, DM1A is also significant), although in these equations one of the simple-sum measures is also significant (for SSM1A). With respect to monetary causality in the United States, TB equations, both simple sum and Divisia seem to do equally well in that each measure has significant strikes.

The U.K. evidence, reported in Table 17, contrasts sharply with that for Switzerland. Neither M4 nor Divisia M4 affects real GNP. However, Divisia M4 does influence the inflation rate. Both money measures influence interest rates. Thus, the superiority of Divisia M4 over M4 is confirmed (at least so far as inflation is concerned), but the lack of causality from money to real activity is noteworthy.

The Australian results, recorded in Table 18, differ from the U.S. results in that the TB rate does not have a significant short-run influence in any of the real output equations or in the price equations. However, in common with the U.S. results, Divisia money is significant—both M2 and M3—in the real output equation, whereas the simple-sum measures are not. In contrast, however, it is the simple-sum measures which have a significant short-run impact in the TB equations rather than the Divisia measures. There are also significant long-run influences in all of the equations, although these do not seem to be confined to any particular measure of money.

For Germany, none of the monetary impulses —neither Divisia nor simple-sum—appears with a significant influence in the real output equations, although there would appear to be an interest rate effect in this equation for the two sum measures of money. Real GDP has a significant influence in all of the money equations, apart from SSM2. The joint effect of the TB rate is significant in all of the money equations and inflation, in turn, has a significant impact on interest rates.

Both simple-sum and Divisia monetary measures have also a significant influence on inflation and the TB rate in the Swiss case (Table 20), although in contrast to the German case

Table 18

Causality Tests for Australia

	SSM2	GDP	DEF	TB
SSM2	18.76 (0.00)	9.05 (0.06)	7.06 (0.13)	18.18 (0.00)
GDP	3.21 (0.52)	16.06 (0.00)	30.92 (0.00)	3.45 (0.48)
DEF	5.40 (0.25)	17.95 (0.00)	19.35 (0.00)	5.33 (0.25)
TB	21.29 (0.00)	2.51 (0.64)	6.18 (0.18)	13.15 (0.01)
ECM	0.68 (0.41)	2.32 (0.12)	0.07 (0.79)	8.68 (0.00)
	DM2	**GDP**	**DEF**	**TB**
DM2	19.24 (0.00)	9.15 (0.00)	4.24 (0.37)	3.87 (0.42)
GDP	4.07 (0.39)	15.68 (0.00)	22.32 (0.00)	4.91 (0.79)
DEF	6.08 (0.19)	16.68 (0.00)	19.61 (0.00)	4.01 (0.40)
TB	4.49 (0.34)	4.24 (0.37)	4.75 (0.31)	11.81 (0.02)
ECM	4.07 (0.04)	8.07 (0.00)	3.59 (0.06)	0.70 (0.40)
	SSM3	**GDP**	**DEF**	**TB**
SSM3	17.40 (0.00)	7.27 (0.12)	2.91 (0.57)	9.72 (0.04)
GDP	15.78 (0.00)	11.46 (0.02)	38.99 (0.00)	4.66 (0.32)
DEF	10.38 (0.03)	12.67 (0.01)	18.73 (0.20)	5.74 (0.22)
TB	12.91 (0.01)	2.67 (0.61)	6.21 (0.18)	19.21 (0.00)
ECM	18.76 (0.00)	10.14 (0.00)	7.54 (0.02)	6.52 (0.04)
	DM3	**GDP**	**DEF**	**TB**
DM3	27.15 (0.00)	14.94 (0.00)	2.53 (0.64)	1.47 (0.83)
GDP	4.24 (0.37)	24.13 (0.00)	30.65 (0.00)	5.45 (0.24)
DEF	7.99 (0.09)	24.23 (0.00)	15.79 (0.00)	6.71 (0.15)
TB	5.05 (0.28)	4.99 (0.28)	4.88 (0.29)	11.33 (0.02)
ECM	0.13 (0.72)	5.41 (0.02)	0.02 (0.88)	6.78 (0.00)

Note: See Table 16.

Table 21
Causality Tests for Canada

	SSM1	GNP	DEF	TB
SSM1	3.48 (0.48)	10.22 (0.03)	4.79 (0.31)	2.77 (0.54)
GNP	6.32 (0.18)	7.11 (0.13)	3.27 (0.51)	11.55 (0.02)
DEF	2.09 (0.72)	15.89 (0.00)	10.53 (0.03)	5.54 (0.23)
TB	8.94 (0.06)	1.91 (0.75)	3.98 (0.41)	16.95 (0.00)
ECM	15.08 (0.00)	11.46 (0.00)	1.80 (0.40)	9.02 (0.01)
	DM1	**GNP**	**DEF**	**TB**
DM1	5.39 (0.25)	8.89 (0.06)	5.16 (0.27)	3.82 (0.43)
GNP	11.20 (0.02)	7.09 (0.13)	5.95 (0.20)	9.65 (0.04)
DEF	2.34 (0.67)	34.00 (0.00)	16.58 (0.00)	7.17 (0.12)
TB	7.88 (0.09)	9.18 (0.05)	1.39 (0.84)	16.68 (0.00)
ECM	16.96 (0.00)	46.18 (0.00)	0.68 (0.71)	5.01 (0.08)
	SSM2	**GNP**	**DEF**	**TB**
SSM2	22.25 (0.00)	6.65 (0.16)	12.36 (0.01)	4.62 (0.33)
GNP	5.24 (0.76)	2.75 (0.60)	4.74 (0.31)	15.11 (0.00)
DEF	10.13 (0.04)	7.57 (0.11)	29.68 (0.00)	19.07 (0.00)
TB	49.24 (0.00)	5.11 (0.28)	6.06 (0.19)	11.16 (0.02)
ECM	0.04 (0.83)	9.85 (0.00)	0.68 (0.41)	0.78 (0.38)
	DM2	**GNP**	**DEF**	**TB**
DM2	30.89 (0.00)	1.24 (0.84)	5.46 (0.24)	6.97 (0.14)
GNP	8.97 (0.06)	2.02 (0.73)	2.89 (0.68)	12.25 (0.01)
DEF	8.61 (0.07)	11.33 (0.02)	19.24 (0.00)	19.59 (0.00)
TB	25.85 (0.00)	2.41 (0.66)	3.54 (0.47)	9.88 (0.04)
ECM	2.81 (0.09)	7.53 (0.00)	0.60 (0.44)	0.11 (0.74)

both Divisia measures appear significant in the output equation, as does SSM1. In common with a number of other countries, the TB rate has a statistical influence in all of the output equations and in three of the money equations. It is noteworthy that the joint effect of inflation is statistically significant in three out of four of the output equations.

The Canadian results (Table 21) portray little significant impact of money on any variable (the exceptions being SSM3 and DM3 in the TB equation). Interest rates also do not have the same significant role to play as they did in the U.S. case for real output, although they do feature in the majority of money equations. The effects of price (or, more correctly, inflation) feature prominently in almost all of the TB equations.

The Japanese causality pattern (reported in Table 22) is in many ways similar to that for Germany. Thus, neither simple-sum nor Divisia money enters significantly into the output equation, although there is a significant impact of both types of money in the inflation and TB equations. The TB rate also features significantly in all of the Japanese real output equations but, in contrast to the German case, only enters significantly into one other equation (apart from its own lags)—that for DM3.

Table 21 (continued)

Causality Tests for Canada

	SSM3	GNP	DEF	TB
SSM3	64.96 (0.00)	6.30 (0.17)	7.25 (0.12)	13.12 (0.01)
GNP	8.25 (0.08)	4.25 (0.37)	7.24 (0.12)	15.93 (0.00)
DEF	7.34 (0.12)	8.13 (0.08)	20.25 (0.00)	27.09 (0.00)
TB	16.58 (0.00)	7.00 (0.14)	9.04 (0.06)	10.08 (0.04)
ECM	0.00 (0.95)	13.33 (0.00)	0.34 (0.56)	1.02 (0.31)
	DM3	**GNP**	**DEF**	**TB**
DM3	22.32 (0.00)	1.27 (0.86)	5.27 (0.26)	10.69 (0.03)
GNP	12.82 (0.01)	4.67 (0.32)	4.01 (0.40)	13.26 (0.01)
DEF	26.96 (0.00)	6.08 (0.19)	18.74 (0.00)	21.38 (0.00)
TB	13.52 (0.00)	1.88 (0.76)	3.00 (0.56)	7.74 (0.10)
ECM	2.96 (0.23)	12.18 (0.00)	1.20 (0.55)	0.52 (0.77)
	SSL	**GNP**	**DEF**	**TB**
SSL	15.36 (0.00)	1.63 (0.80)	0.97 (0.91)	6.39 (0.17)
GNP	3.51 (0.48)	1.67 (0.79)	4.97 (0.29)	11.61 (0.02)
DEF	3.98 (0.41)	11.92 (0.02)	20.64 (0.00)	20.11 (0.00)
TB	7.50 (0.11)	1.78 (0.86)	3.87 (0.42)	14.04 (0.00)
ECM	1.15 (0.78)	11.48 (0.00)	0.51 (0.48)	0.57 (0.45)
	DL	**GNP**	**DEF**	**TB**
DL	59.15 (0.00)	1.38 (0.84)	1.38 (0.84)	4.19 (0.38
GNP	14.29 (0.00)	2.25 (0.68)	3.98 (0.41)	9.38 (0.05)
DEF	15.84 (0.00)	9.52 (0.04)	21.27 (0.00)	16.82 (0.00)
TB	9.34 (0.05)	2.04 (0.73)	3.78 (0.44)	10.11 (0.04)
ECM	1.97 (0.16)	8.55 (0.00)	0.58 (0.44)	0.09 (0.76)

Note: See Table 16.

We may summarize the results reported in this section in the following way. First, there appear to be countries in which Divisia money has greater informational content than simple-sum money and this is most clear in the U.S. and Australian cases. This is possibly because the pace of financial innovation has varied across countries. Such differential impacts across countries also holds true for other variables. In particular, the widely cited effect that the interest rate has in U.S. causality tests does not seem to carry over to other countries. Also, although Divisia money does not have a significant impact in all countries, the evidence for the United Kingdom suggests that this, at least in part, may be attributable to the sophistication with which the Divisia measure is constructed. Thus, although none of the U.K. Divisia measures has a significant effect on real output, the Bank of England Divisia measure (BOED) does have significant informational content for inflation. This measure is widely regarded as being superior to the other measures, perhaps because the Bank economists had access to detailed data on asset compositions which are not publicly available.

Table 22
Causality Tests for Japan

	SSM1	GNP	DEF	TB
SSM1	6.82 (0.15)	1.69 (0.79)	4.30 (0.37)	8.37 (0.07)
GNP	4.81 (0.31)	25.08 (0.00)	3.82 (0.43)	3.47 (0.48)
DEF	2.56 (0.63)	7.61 (0.11)	32.52 (0.00)	7.85 (0.09)
TB	3.84 (0.43)	9.83 (0.04)	7.39 (0.12)	10.65 (0.00)
ECM	10.66 (0.00)	12.33 (0.00)	6.55 (0.04)	10.94 (0.00)
	DM1	**GNP**	**DEF**	**TB**
DM1	11.93 (0.02)	1.46 (0.83)	3.97 (0.41)	8.89 (0.06)
GNP	5.25 (0.26)	24.64 (0.00)	3.75 (0.44)	3.39 (0.49)
DEF	2.21 (0.69)	8.04 (0.08)	34.01 (0.00)	7.92 (0.09)
TB	4.57 (0.33)	9.17 (0.06)	7.17 (0.13)	19.25 (0.00)
ECM	11.36 (0.00)	12.17 (0.00)	6.54 (0.04)	11.16 (0.00)
	SSM2	**GNP**	**DEF**	**TB**
SSM2	39.02 (0.00)	1.10 (0.89)	10.41 (0.03)	14.06 (0.00)
GNP	6.02 (0.19)	21.36 (0.00)	4.33 (0.36)	6.16 (0.18)
DEF	7.75 (0.10)	6.37 (0.17)	35.58 (0.00)	5.18 (0.27)
TB	7.13 (0.13)	12.22 (0.02)	7.10 (0.13)	17.47 (0.00)
ECM	9.15 (0.01)	14.14 (0.00)	3.61 (0.16)	10.97 (0.00)
	DM2	**GNP**	**DEF**	**TB**
DM2	57.64 (0.00)	1.04 (0.90)	11.72 (0.02)	11.08 (0.03)
GNP	4.36 (0.36)	22.02 (0.00)	3.92 (0.42)	4.48 (0.34)
DEF	9.19 (0.05)	8.15 (0.08)	34.41 (0.00)	8.04 (0.09)
TB	8.84 (0.06)	14.81 (0.00)	6.40 (0.17)	21.34 (0.00)
ECM	6.83 (0.03)	13.31 (0.01)	3.78 (0.15)	15.57 (0.00)
	SSM3	**GNP**	**DEF**	**TB**
SSM3	47.24 (0.00)	0.74 (0.94)	8.53 (0.07)	13.92 (0.01)
GNP	4.06 (0.39)	19.25 (0.00)	3.44 (0.48)	7.37 (0.11)
DEF	6.97 (0.14)	6.39 (0.17)	34.03 (0.00)	6.49 (0.16)
TB	7.03 (0.13)	10.49 (0.03)	6.97 (0.14)	17.58 (0.00)
ECM	7.74 (0.02)	12.69 (0.00)	3.57 (0.16)	10.03 (0.00)
	DM3	**GNP**	**DEF**	**TB**
DM3	66.52 (0.00)	0.73 (0.94)	12.16 (0.02)	10.93 (0.02)
GNP	3.19 (0.53)	20.91 (0.00)	3.23 (0.52)	4.59 (0.33)
DEF	9.70 (0.04)	8.13 (0.08)	33.71 (0.00)	8.20 (0.08)
TB	9.41 (0.05)	13.93 (0.00)	6.40 (0.17)	21.08 (0.00)
ECM	6.07 (0.05)	13.05 (0.00)	3.87 (0.14)	14.56 (0.00)

Note: See Table 16.

Table 23

Estimated Trace and λMax Statistics: United States Sub-Samples

TRACE (LR1)											
SSM1	DM1	SSM1A	DM1A	SSM2	DM2	SSM3	DM3	SSL	DL	RCE	BCE
1.02	0.86	0.02	0.57	3.25	0.02	0.83	0.01	1.44	0.06	6.07	0.16
11.23	12.42	12.96	13.50	18.55	10.29	12.11	11.13	14.31	1.44	20.99	9.01
29.31	30.18	30.33	29.34	36.89	27.23	27.47	27.33	34.77	28.69	41.70	30.04
53.90	53.92	52.67	51.00	62.29	49.45	54.19	50.09	63.07	50.37	67.90	56.69

λMAX (LR2)											
SSM1	DM1	SSM1A	DM1A	SSM2	DM2	SSM3	DM3	SSL	DL	RCE	BCE
1.02	0.86	0.02	0.57	3.25	0.02	0.83	0.01	1.44	0.06	6.08	0.16
10.22	11.56	12.93	13.44	15.30	10.28	11.29	11.12	12.86	9.38	9.38	8.84
18.07	17.76	17.37	15.84	17.34	16.94	15.35	16.19	20.46	20.46	20.46	21.03
24.60	23.74	22.34	21.66	26.40	22.21	26.72	22.76	28.91	28.91	26.28	26.66

Sub-Sample Results for the United States: the Post-1979 Regime Change

The causality results reported in the previous section are for the longest span of data for which consistent simple-sum and Divisia data are available for each country. Within each country-specific data sample, there may be one or two changes in the way monetary policy has been implemented. Thus, some countries have switched from targeting one particular aggregate to another or have switched from monetary targeting to interest rate targeting, or vice versa. Therefore, it is of interest to inquire if the results reported in the previous section carry through for sub-samples corresponding to specific monetary regimes. One of the possible examples of a regime change arises in the United States around 1980, when a combination of reforms (including a change in Fed operating procedure and a liberalization of deposit markets) produced an apparent shift in previously stable monetary relationships (Rasche 1993). Given this, and also since the U.S. data sample is one of the longest, we concentrate our sub-sample tests on our U.S. data set. In particular, we have re-estimated our U.S. causality tests for the first quarter of 1960 to the third quarter of 1979 (lags being generated within this sample).

In Table 23, the estimated Trace and λmax statistics are reported for our chosen U.S. sub-sample. In contrast to the full sample results, it is noteworthy that all of the monetary measures produce at least one cointegrating vector (for the full sample, none of the M1 monetary measures produced any cointegrating vectors). We therefore use the information concerning the number of cointegrating vectors to set up appropriate VECMs for each monetary measure. The sub-sample exclusion tests based upon these VECMs are reported in Table 24. The broad conclusion to emerge from this table is, perhaps not surprisingly, that the sub-sample produces a very different picture with respect to the relative merits of simple-sum and Divisia money. More specifically, we note that the significant impact of money in the real output equations occurs for the narrow M1 measures of money and not for the broader measures (and, in terms of the M1 measures, simple sum seems to outperform Divisia since two of the sum measures are significant at the 5 percent level against one Divisia measure at this significance level). Of the two currency equivalent measures, RCE is insignificant in the GDP equation, while BCE is significant (albeit at the 6 percent level of significance) the reverse of our findings for the full sample. Other notable features of the sub-sample results, which are dis-

Table 24
Sub-Sample Causality Tests for the United States

	SSM1	GDP	DEF	TB
SSM1	57.23 (0.00)	11.28 (0.02)	13.04 (0.01)	32.78 (0.00)
GDP	5.87 (0.21)	2.44 (0.65)	1.98 (0.74)	6.99 (0.14)
DEF	8.87 (0.06)	5.34 (0.25)	39.38 (0.00)	1.11 (0.89)
TB	15.20 (0.00)	5.94 (0.20)	6.52 (0.16)	41.57 (0.00)
ECM	5.55 (0.02)	9.99 (0.00)	0.42 (0.52)	0.49 (0.48)
	DM1	**GDP**	**DEF**	**TB**
DM1	27.14 (0.00)	10.69 (0.03)	15.16 (0.00)	18.57 (0.00)
GDP	0.62 (0.96)	4.29 (0.37)	3.53 (0.47)	8.27 (0.08)
DEF	3.80 (0.43)	7.31 (0.12)	11.99 (0.02)	1.04 (0.90)
TB	22.95 (0.00)	5.28 (0.26)	8.33 (0.08)	22.31 (0.00)
ECM	1.20 (0.27)	10.22 (0.00)	3.29 (0.07)	0.03 (0.87)
	SSM1A	**GDP**	**DEF**	**TB**
SSM1A	40.06 (0.00)	10.76 (0.03)	16.73 (0.00)	30.93 (0.00)
GDP	7.13 (0.13)	3.64 (0.46)	4.18 (0.38)	5.72 (0.22)
DEF	4.79 (0.31)	6.82 (0.14)	20.98 (0.00)	0.41 (0.98)
TB	15.13 (0.00)	5.14 (0.27)	8.94 (0.06)	42.39 (0.00)
ECM	1.81 (0.18)	10.80 (0.00)	2.96 (0.08)	0.04 (0.83)
	DM1A	**GDP**	**DEF**	**TB**
DM1A	26.63 (0.00)	8.14 (0.08)	19.14 (0.00)	17.75 (0.00)
GDP	0.85 (0.93)	4.69 (0.32)	7.34 (0.12)	7.02 (0.13)
DEF	3.74 (0.44)	8.36 (0.08)	4.94 (0.29)	0.22 (0.99)
TB	25.91 (0.00)	5.31 (0.26)	11.08 (0.03)	23.14 (0.00)
ECM	0.00 (0.97)	9.33 (0.00)	7.17 (0.00)	0.12 (0.73)

tinct from the full sample results, include the finding of a strongly significant effect of money on the deflator for all measures of money (except RCE) and a much less important role for the interest rate in the output equation. (The TB rate is only significant in two instances, whereas it was significant in all cases for the full sample.)

CONCLUSION

The evidence from the St. Louis equations is fairly straightforward: Divisia weighted aggregates appear to offer advantages over broad simple-sum monetary aggregates. The credibility of narrow simple-sum aggregates has universally been undermined by the spread of financial innovation. Although results of our real income causality tests are less persuasive. However, they still give a clear edge to Divisia aggregates over simple sum. The results are not so strong that we can conclude that Divisia money matters while simple sum does not. Nonetheless, it is clear from the U.S. evidence that the advantages of Divisia are particularly strong after 1980, the period in which financial innovation is greatest. Pre-1980 data do not show any support for Divisia. It may well be that if we could base our tests on post-1980 data alone, we would find much stronger support for Divisia. Also, the existence of reverse causality (from real income to money) is not particularly surprising given the fact that most authorities are pegging short-term interest rates or exchange rates. Superficially, this would support the "real business cycle" view or even the "money doesn't

Table 24 (continued)

Sub-Sample Causality Tests for the United States

	SSM2	GDP	DEF	TB
SSM2	45.44 (0.00)	6.54 (0.16)	11.22 (0.02)	17.30 (0.00)
GDP	3.53 (0.47)	7.48 (0.11)	2.93 (0.57)	7.22 (0.12)
DEF	5.73 (0.22)	9.99 (0.04)	1.14 (0.88)	4.03 (0.40)
TB	46.46 (0.00)	2.02 (0.73)	6.48 (0.17)	35.07 (0.00)
ECM	8.08 (0.01)	15.69 (0.00)	9.66 (0.00)	1.38 (0.50)
	DM2	**GDP**	**DEF**	**TB**
DM2	45.70 (0.00)	6.06 (0.19)	17.51 (0.00)	8.73 (0.07)
GDP	5.31 (0.26)	9.10 (0.06)	4.16 (0.39)	10.08 (0.04)
DEF	4.53 (0.34)	5.14 (0.27)	20.15 (0.00)	5.75 (0.22)
TB	76.87 (0.00)	2.69 (0.61)	8.02 (0.09)	26.04 (0.00)
ECM	3.63 (0.05)	0.16 (0.69)	3.26 (0.07)	2.13 (0.14)
	SSM3	**GDP**	**DEF**	**TB**
SSM3	74.22 (0.00)	1.01 (0.91)	20.52 (0.00)	4.88 (0.29)
GDP	5.00 (0.29)	5.27 (0.26)	7.44 (0.11)	7.26 (0.12)
DEF	4.35 (0.36)	9.62 (0.05)	2.72 (0.61)	1.99 (0.74)
TB	15.43 (0.00)	10.61 (0.03)	11.13 (0.03)	25.20 (0.00)
ECM	4.23 (0.04)	10.22 (0.00)	14.81 (0.00)	0.79 (0.37)
	DM3	**GDP**	**DEF**	**TB**
DM3	98.38 (0.00)	2.89 (0.57)	18.94 (0.00)	9.85 (0.04)
GDP	8.00 (0.09)	5.71 (0.22)	9.10 (0.06)	4.34 (0.36)
DEF	9.88 (0.04)	8.99 (0.06)	2.68 (0.61)	0.94 (0.92)
TB	38.56 (0.00)	3.23 (0.52)	18.72 (0.00)	25.78 (0.00)
ECM	6.14 (0.01)	10.94 (0.00)	9.25 (0.00)	0.18 (0.67)

matter" view. However, it may instead be the old problem of observational equivalence.

The policy significance of these results may be limited. Monetary authorities can no more control Divisia aggregates than they can broad money. However, Divisia aggregates undoubtedly offer potential information to monetary authorities about the relative ease or tightness of monetary stance—much more so than do broad simple-sum aggregates. However, the body of research supporting Divisia is not yet sufficiently large or robust that we would wish to recommend direct targeting at this stage. What is important, however, is that official credible Divisia index numbers should be produced so that researchers can test exhaustively the performance of these indicators. Only when a clear consensus emerges should policy be directly linked to such indicators. Just because an indicator does well in the 1980s does not mean it will do well in the 1990s. Divisia aggregates did particularly well at handling the introduction of interest on checking accounts. They may be less useful in a period of, say, the widespread adoption of "smart" cards.

In short, while our results are encouraging enough to suggest that monetary authorities should commission further work on Divisia, the picture which emerges is not sufficiently clear-cut to lead to immediate policy recommendations. However, the message for the economics profession is much clearer. All those who do applied research using money should take on board the fact that simple-sum measures are substantially distorted and a better measure is likely to be provided by a monetary services index constructed along something like Divisia lines. Rejections of the role of money based upon flawed money measures are themselves easy to reject.

REFERENCES

Barnett, William A. "The Optimal Level of Monetary Aggregation," *Journal of Money, Credit and Banking* (November 1982, part 2), pp. 687–710.

________. "Economic Monetary Aggregates: An Application of Index Number and Aggregation Theory," *Journal of Econometrics* (September 1980), pp. 11–48.

________, Douglas Fisher, and Apostolos Serletis. "Consumer Theory and the Demand for Money," *Journal of Economic Literature* (December 1992), pp. 2086–119.

________, Edward K. Offenbacher, and Paul A. Spindt. "The New Divisia Monetary Aggregates," *Journal of Political Economy* (December 1984), pp. 1049–85.

________, and Paul A. Spindt. "The Velocity Behavior and Informational Content of Divisia Monetary Aggregates," *Economics Letters*, vol. 4 (1979), pp. 51–7.

Basmann, R.L. "The Causal Interpretation of Non-Triangular Systems of Economic Relations," *Econometrica* (July 1963), pp. 439–48.

Belongia, Michael T. "Measurement Matters: Recent Results from Monetary Economics Re-examined," manuscript, 1993.

________, and James A. Chalfant. "The Changing Empirical Definition of Money: Some Estimates from a Model of the Demand for Money Substitutes," *Journal of Political Economy* (April 1989), pp. 387–97.

________, and K. Alec Chrystal. "An Admissible Monetary Aggregate for the United Kingdom," *The Review of Economics and Statistics* (August 1991), pp. 497–502.

Boulding, Kenneth. "Minutes of Session V: How Does Monetary Policy Affect the Economy?" *Journal of Money, Credit and Banking* (August 1969), p. 555.

Campbell, John Y., and Pierre Perron. "Pitfalls and Opportunities: What Macroeconomists Should Know about Unit Roots," *NBER Macroeconomics Annual* (1991), pp. 141–201.

Chetty, V. Karuppan. "On Measuring the Nearness of Near-Moneys," *The American Economic Review* (June 1969), pp. 270–81.

Chrystal, K. Alec, and Ronald MacDonald. "Exchange Rates and Financial Innovation: The Sterling Dollar Rate 1972-90." Paper presented to Conference of American Statistical Association, held at San Francisco, August 1993.

Cockerline, Jon P., and John D. Murray. "A Comparison of Alternative Methods of Monetary Aggregation: Some Preliminary Evidence," *Bank of Canada Technical Report #28* (November 1981).

Cooley, Thomas F., and Stephen F. LeRoy. "Atheoretical Macroeconomics: A Critique," *Journal of Monetary Economics* (November 1985), pp. 238–308.

De Long, J. Bradford, and Lawrence H. Summers. "How Does Macroeconomic Policy Affect Output?" *Brookings Papers on Economic Activity*, 2:1988, pp. 433–80.

Dickey, David A., and Wayne A. Fuller. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root," *Journal of the American Statistical Association* (June 1979), pp. 427–31.

Diewert, W.E. "Superlative Index Numbers and Consistency in Aggregation," *Econometrica* (July 1978), pp. 883–900.

________. "Exact and Superlative Index Numbers," *Journal of Econometrics* (May 1976), pp. 115–45.

Drake, L., and K. Alec Chrystal. "Sectoral Money Demand," *Journal of Money, Credit and Banking* (forthcoming).

Engle, Robert F., and C.W.J. Granger. "Co-integration and Error Correction: Representation, Estimation and Testing," *Econometrica* (March 1987), pp. 251–76.

Fisher, Andrew. "Bundesbank criticized by chief economist of Germany's largest commercial bank" and "Bundesbank told it should drop reliance on M3," *Financial Times*, August 10, 1993.

Fisher, Douglas. *Money Demand and Monetary Policy.* Harvester Wheatsheaf, 1989.

________, and Apostolos Serletis. "Velocity and the Growth of Money in the United States 1970-85," *Journal of Macroeconomics* (summer 1989), pp. 323–32.

Fisher, Paul, Suzanne Hudson, and Mahmood Pradhan. "Divisia Indices for Money: An Appraisal of Theory and Practice," *Bank of England Working Paper Series #9* (April 1993).

Friedman, Benjamin M., and Kenneth N. Kuttner. "Another Look at the Evidence on Money-Income Causality," *Journal of Econometrics* (May/June 1993), pp. 189–203.

________, and ________. "Money, Income Prices and Interest Rates," *The American Economic Review* (June 1992), pp. 472–92.

Friedman, Milton. *A Program for Monetary Stability.* Fordham University Press, 1959.

Fuller, Wayne A. "Introduction to Statistical Time Series." John Wiley and Sons, 1976.

Hall, Alastair. "Testing for a Unit Root in Time Series with Pretest Data Based Model Selection," *Journal of Business and Economic Statistics* (forthcoming).

Hansen, Lars Peter. "Large Sample Properties of Generalized Method of Moments Estimators," *Econometrica* (July 1982), pp. 1029–54.

Holmes, James M., and Patricia A. Hutton. "A New Test of Money-Income Causality," *Journal of Money, Credit and Banking* (August 1992), pp. 338–55.

Horne, Jocelyn, and Vance L. Martin. "Weighted Monetary Aggregates: An Empirical Study Using Australian Monetary Data, 1969-87," *Australian Economic Papers* (December 1989), pp. 181–200.

Hostland, Doug, Stephen Poloz, and Paul Storer. "An Analysis of the Information Content of Alternative Monetary Aggregates," *Bank of Canada Technical Reports #48* (October 1987).

Ishida, Kazuhiko. "Divisia Monetary Aggregates and Demand for Money: A Japanese Case," *Bank of Japan Monetary and Economic Studies* (June 1984), pp. 49–80.

Johansen, Soren. "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models," *Econometrica* (November 1991), pp. 1551–80.

________. "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamics and Control* (June/Sept. 1988), pp. 231–54.

________, and Katarina Juselius. "Maximum Likelihood Estimation and Inference on Cointegration - with Applications to the Demand for Money," *Oxford Bulletin of Economics and Statistics* (May 1990), pp. 169–210.

Keynes, John Maynard. *A Treatise on Money*, volume I (The Pure Theory of Money). Harcourt, Brace and Company, 1930a.

________. *A Treatise on Money*, volume II (The Applied Theory of Money). Harcourt, Brace and Company, 1930b.

Lindsey, David E., and Paul Spindt. "An Evaluation of Monetary Indexes," *Special Studies Paper #195*. Board of Governors of the Federal Reserve System, Division of Research and Statistics, March 1986.

MacDonald, Ronald, and Colm Kearney. "On the Specification of Granger-Causality Tests Using the Cointegration Methodology," *Economics Letters*, vol. 25 (1987), pp. 149–53.

Park, Joon Y., and Buhmsoo Choi. "A New Approach to Testing for a Unit Root," Cornell University, Center for Analytic Economics, Working Paper #88-23 (May 1988).

Perron, Pierre. "Trends and Random Walks in Macroeconomic Time Series: Further Evidence from a New Approach," *Journal of Economic Dynamics and Control* (June-September 1988), pp. 297–332.

Phillips, Peter C.B., and Pierre Perron. "Testing for a Unit Root in Time Series Regression," *Biometrika* (June 1988), pp. 335–46.

Plosser, Charles I. "Money and Business Cycles: A Real Business Cycle Interpretation," in Michael T. Belongia, ed., *Monetary Policy on the 75th Anniversary of the Federal Reserve System* (Proceedings of the 14th Annual Economic Policy Conference of the Federal Reserve Bank of St. Louis). Kluwer Academic Publishers, 1991, pp. 245–74.

Rasche, Robert H. "Monetary Aggregates, Monetary Policy and Economic Activity," this *Review* (March/April 1993), pp. 1–35.

Rotemberg, Julio J. "Commentary: Monetary Aggregates and their Uses," in Michael T. Belongia, ed., *Monetary Policy on the 75th Anniversary of the Federal Reserve System* (Proceedings of the 14th Annual Economic Policy Conference of the Federal Reserve Bank of St. Louis). Kluwer Academic Publishers, 1991, pp. 223–31.

Serletis, Apostolos. "The Empirical Relationship between Money, Prices and Income Revisited," *Journal of Business and Economics Statistics* (July 1988), pp. 351–8.

Sims, Christopher. "Comparison of Interwar and Postwar Business Cycles: Monetarism Reconsidered," *The American Economics Review* (May 1980), pp. 250–7.

Stock, James H. "A Class of Tests for Integration and Cointegration," mimeo, Harvard University, May 1990.

________, and Mark W. Watson. "Interpreting the Evidence on Money-income Causality," *Journal of Econometrics* (January 1989), pp. 161–81.

White, Halbert. "A Heteroskedasticity-Consistent Covariance Matrix and a Direct Test for Heteroskedasticity," *Econometrica* (May 1980), pp. 817–38.

Yue, Piyu, and Robert Fluri. "Divisia Monetary Services Indexes for Switzerland: Are They Useful for Monetary Targeting?" this *Review* (September/October 1991), pp. 19–33.

Zellner, Arnold. "Causality and Causal Laws in Economics," *Journal of Econometrics* Annals 1988-3, p. 7–21.

________. "Causality and Econometrics," in *Three Aspects of Policy and Policy Making: Knowledge, Data and Institutional Conference* (Carnegie-Rochester Conference Series on Public Policy, April 1978), 1979, pp. 9–54.